Bulk power facilities Eastern Ontario

Submission to the
Royal Commission on
Electric Power Planning
December 1978

Requirement for Additional Bulk Power Facilities
To Supply Eastern Ontario

Submission of

ONTARIO HYDRO

to the

Royal Commission

on Electric Power Planning

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1.0 Introduction

On July 11, 1974 the Ontario Government announced that it would hold public hearings into the long-range planning of Ontario's electric power system. On March 13, 1975, the Honourable Allan Grossman, Provincial Secretary for Resources Development, announced in the Legislature the Government's decision to establish an independent commission of enquiry to hold these hearings. He stated, "The Commission will focus on the broad conceptual consequences of alternative ways of supplying electric power during the period 1983-1993". The March 13, 1975 statement also noted that there are certain electric power generating and transmission projects that Ontario Hydro considers must be initiated during the tenure of the Commission, and that the Commission would look into the need for these projects. Accordingly, a submission was made by Ontario Hydro in November, 1977 to the Royal Commission on Electric Power Planning (RCEPP) entitled "The Requirement for Additional Bulk Power Facilities to Supply Eastern Ontario." Since the time of that submission, the terms of reference of the Commission with respect to the Priority Projects have been modified, and there has been a significant change in Ontario Hydro's load forecast for Eastern Ontario.

Accordingly, this submission takes account of these changes, and supersedes the November 1977 submission.

The revised terms of reference with respect to the priority projects, outlined in Order-In-Council 2065/78, dated July 12, 1978 are attached to this submission as Appendix A.

This submission considers the need or requirement for additional bulk power supply facilities in eastern Ontario, which is defined in the Commission's terms of references as being that portion of Ontario east of Lennox Generating Station. The submission also presents the forecast load growth in this area to the year 2000.

There will be three future requirements for major new supply facilities in eastern Ontario:

A. Load Supply

The most urgent requirement is to supply the growing load in eastern Ontario.

B. Interconnections

Another requirement is to reinforce the interconnections with New York State and Quebec. An interconnection is a transmission line which directly connects adjacent electric utilities. Interconnections provide advantages in the areas

of improved system reliability and reduced costs, as discussed in some detail in the Ontario Hydro Information Memorandum to the Royal Commission on Electric Power Planning, entitled "System Interconnections", dated June 1976 (Exhibit 23-0).

The Ontario Hydro System has for many years been interconnected with the system of the Power Authority of the State of New York (PASNY) at Cornwall. This is one of the interconnections whereby Ontario Hydro's system is operated in synchronism with the large power grid covering much of eastern North America.

Ontario Hydro also has major interconnections with Quebec in eastern Ontario, but because of the nature of the Hydro-Quebec system, which comprises large hydraulic generating stations connected by long transmission lines to load centres in Montreal and Quebec City, it is not possible for the Ontario Hydro and the Hydro-Quebec systems to operate in synchronism. Therefore, Hydro-Quebec supplies power to Ontario by disconnecting generation from its system and connecting it to the Ontario system via the interconnections. In a similar manner, Ontario Hydro can assist Quebec in emergencies but to a very limited extent because Ontario Hydro's transmission system does not permit easy isolation of major blocks of generation. Furthermore, unless additional transmission is installed in eastern Ontario, any disconnection of facilities to supply power to Hydro-Quebec would jeopardize the supply to Ottawa. Interconnection by isolating generation does not provide the operating flexibility which is achieved when systems operate in parallel.

If the advantages of interconnections are to be retained as systems grow in size, their capacity must be increased, but the timing for increases in the capacity of the interconnections in eastern Ontario is less urgent than for load supply facilities.

C. <u>Incorporation of Future Generating Stations</u>

The third requirement for new transmission is to incorporate future generating stations. It is expected that before the year 2000 there will be one or two additional thermal generating stations located in eastern Ontario. The incorporation of this new generation into the bulk power system would require new transmission facilities. Since any such station could not be in service before the early 1990's, this transmission requirement will not occur as soon as that for load supply.

Since the first of the three requirements discussed above, for load supply, is the most urgent, the remainder of this submission discusses the expected load growth, the existing facilities, and the timing of the need for new facilities to supply the load.

2.0 Load Growth

2.1 General

For purposes of administration, the Ontario Hydro System is divided into operating areas. The geographic area of Ontario east of Lennox Generating Station is closely approximated by the area within six of these operating areas namely; Vankleek Hill, Winchester, Arnprior, Perth, Brockville and Kingston. The actual and forecast loads for December for each of these areas and the total for the six areas are tabulated in Figure 1. The location of these areas and a graphical representation of the forecasts are shown in Figure 2.

December values are used to indicate the growth trends because the historical records are more readily available, although, as stated below, January loads are used to assess system requirements.

The load in each operating area comprises three components:

A. Municipal
The power supplied to the municipalities for re-sale.

B. Retail
The power supplied by Ontario Hydro to retail customers outside the municipalities.

C. Direct Industrials
The power supplied directly by Ontario Hydro to industrial customers

A subdivision of the load for each area into these components is shown in Figures 3 to 8.

The total load in these six areas varies throughout a day, from day to day, and from season to season. In all seasons, it is highest in the daytime and lowest at night and on weekends. The winter load is higher than the summer and reaches its peak value regularly between 5 and 6 p.m. Figure 9 is an annual load duration curve for the East System showing the variation of the load with percentage of time. It is applicable to the loads in the areas being considered in this study. The peak load over the winter period imposes the most severe duty on the existing

generation and transmission facilities, and for the area under study this is forecast to occur in January. Therefore, the study of system adequacy is based on the load forecast for January.

2.2 Load Forecasting

At least once a year, for an area such as eastern Ontario, a complete review is made of the load forecast for the following ten years. In the interval between the successive annual reviews, the progress of actual load growth and economic conditions is monitored and, if necessary, revised forecasts are issued to reflect conditions different from those contemplated when the last complete annual review was made. These forecasts are made in considerable geographic detail and are based on forecasts, made in the field, of individual wholesale supply users. In this way a wealth of detailed knowledge and experience is brought to bear on the forecast.

Projection of these forecasts to twenty year time horizons is necessarily a hazardous exercise, because so many new variables can come to bear. For example, population can be regarded as virtually fixed in the short run, but in the longer run, it may change considerably in unforeseeable ways.

The smaller an area, the greater is the relative forecast error. For this reason, the long term forecasts are derived by decomposing a forecast of the total. In this, a considerable amount of judgement is exercised, since detailed local information diminishes as the time horizon is extended. In addition, an attempt is made to attach estimates of reliability to the individual forecasts at each level of aggregation.

In making and discussing forecasts, particularly long range forecasts, there may be difficulty in placing current issues in perspective. In the Ottawa area, the current issue is the proposal to move 15,000 civil service jobs to Hull over the next few years. It is estimated that these jobs account for about 20% of the civil service in the Ottawa area. At 0.5 kW per job, the load difference amounts to 7.5 MW or a little less than one percent of the Ottawa area 1976 peak load. If the civil servants who are moved continue to reside in the Ottawa area, as seems likely, the associated residential and commercial load may be affected only to a minor degree. The civil service in the Ottawa area has been expanding annually for many years at a substantial rate. When this is taken into account, the impact of such a move over a period of decades seems unlikely to be significant, if in fact it does take place. A major shift in the growth pattern of the federal government might be significant, provided it were sustained.

2.3 Ottawa Area

The Ottawa-Cornwall area of eastern Ontario is rather heterogeneous insofar as the demand for electricity is concerned. The dynamic influence is the federal government, which is centred in the Ottawa area. In the Canadian economy it has been evidenced since the 1930's that the rate of expansion of the public sector has outpaced that of the private sector. At the present time, the public sector absorbs something in the order of 43% of the real national output. While expenditures by other levels of government tend to grow more rapidly than at the federal level, the latter has also increased its share of the national output. While government is not by itself an intense user of electric energy, it does use labour very intensively, and consequently the Ottawa area population and labour force have tended to grow quite rapidly. This population imposes demands for commercial service, and the result has been a rapid growth in the demand for electric energy over the years to a point where the Ottawa area constitutes one of the major growth centres in the demand for electric energy in Ontario.

The prospects for the growth in the government sector to diminish to a rate below that of the economy as a whole appear to be remote, at least on a sustained basis. This is so even though there is a concerted effort on the part of government to achieve a more moderate rate of total economic growth, since such a policy itself implies greater rather than less activity on the part of government.

Experience in the Ottawa area suggests that an effect is occurring similar to that which occurred in the development of the Toronto metropolitan area in the post-war period. There it has been possible to detect a wave of rapid growth hitting successively more distant communities. This wave has leaped across Highway 401 and is currently affecting places as far away as Markham and Streetsville.

As the wave has moved out from the core of American cities, it has left a vacuum of declining core, but in Canada, there has been something of an implosion resulting in redevelopment of the core in such cities as Montreal, Toronto and Ottawa. The Ottawa evidence suggests that a similar wave is occurring in Gloucester and Nepean Townships, and that this wave is also extending beyond these areas.

Power demands in the regions other than Ottawa, while growing, have tended to exhibit less dynamic load growth characteristics. Much of the industry in the St. Lawrence Valley is centred on textiles, and this has been a somewhat depressed industry for many years. The farming land in eastern Ontario tends to be less

fertile than that in southwestern Ontario, and there has been a tendency to specialize in beef and dairy cattle operations, neither of which is in a particularly robust condition. Eastern Ontario is also a tourist area centred on the St. Lawrence and Rideau River systems, but the tourist industry is not an intensive user of electric energy, and there is no compensating magnitude of scale such as exists in the Ottawa area.

The Ottawa area load as defined for this study comprises all the loads in the immediate Ottawa area, all loads served radially by circuits from stations in the Ottawa area, and any loads connected to the circuits supplying Ottawa. The latter are included since they increase the loading on the critical circuits to Ottawa and cannot readily be served in any other way. As is explained in greater detail in Section 5.3, the supply of the load in the Ottawa area precipitates the earliest requirement for major new facilities and therefore is the one considered in this report. The forecast for the Ottawa area load in megawatts at the time of the area peak is detailed for selected years and is broken down by the transformer stations supplying the area in Figure 10.

Figure 10 also shows the forecast for the total annual energy consumption for the Ottawa area. The growth rate for energy consumption is very nearly the same as for the peak demands.

The Ottawa area load is concentrated and amounts to about 60% of the load in the six operating areas in eastern Ontario, referred to in Section 2.1.

2.4 The SRI-CEA Econometric Model

2.4.1 General

The model was developed by the consulting firm, SRI International, at the request of the Canadian Electrical Association (CEA)*. The purpose of this mathematical model is to project the long term demand for electric energy by end use.

In order to obtain a forecast from the model, it is necessary to make separate forecasts of a number of variables such as population, industrial production and gross domestic provincial product (GDPP), and to estimate the parameters required to provide the dynamic relationship between the variables and the demand for electricity. Therefore, a reasonable forecast is obtained only if reasonable and consistent estimates of the variables are combined with reasonable and consistent estimates of the parameters. Further, the model is structured in such a way that it cannot forecast new relationships between energy use

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* "Long Range Electricity Forecast for Canada - A Metholodology", November, 1978, by SRI International, for the Canadian Electrical Association

and the variables considered or other variables that may be important in the future.

The model was developed quite recently, and Ontario Hydro has had limited experience with its use. A great deal of experience will be required to determine the model's capabilities and limitations. While the economic data required by the model is available on a provincial base, not all of it is available for regions of the Province as required by the study. Other models are also being developed which will provide information for comparison with the SRI-CEA model.

The SRI-CEA model is useful in understanding questions such as the following:

(1) For a set of economic assumptions, what are likely ranges in growth rates for electricity use?

(2) If another Arab oil embargo is initiated (bringing higher oil prices), how will that influence the demand for electricity?

(3) What will be the impact on energy demand of increasing electric rates in the residential, industrial, and commercial sectors?

(4) If gas prices rise rapidly, what impact will that have on the consumption of electricity for residential space and water heating?

(5) How will changes in the expansion rate of the provincial economy affect the use of electricity in residences, in commerce, and in industry?

(6) If a certain industry expands production, what effect will that have on the use of electricity?

(7) Where can effort be best employed to improve the quality of load forecasts?

2.4.2 Model Structure

The conceptual framework used in the SRI-CEA model to forecast energy use is shown in Figure 11. On the right side of the figure are shown the economic variables that influence the demand for energy in each end use application. The end use markets themselves appear in the centre, and the left side shows the energy sources that supply the market. The end uses were selected on the basis of their relative sizes and importance in the marketplace for electricity in Canada. Broadly speaking, the

markets are the residential, agricultural, commercial and industrial (manufacturing and mining) sectors.

For each end use, the quantity of electricity demanded is analytically related to appropriate economic and industrial indicators. The structural form of these relationships was developed based on a consideration of market behaviour, availability of data, simplicity of equation form, and reasonableness of computed results.

The industrial demand for electricity is dependent on the patterns of electricity use and levels of production in specific industries. In industry, pulp and paper, chemical, steel, and aluminum and the mining of iron, copper, and coal each require large quantities of electricity, predominantly for motor drives and electrolytic processing. Thus, future consumption of electricity is directly correlated with industrial production. Electricity use by all other industries, referred to in the SRI-CEA report as "light manufacturing", is correlated with general levels of manufacturing activity, that is, value added in manufacturing.

In the residential sector, three separate markets were analyzed: (1) space heating, (2) water heating, and (3) electric appliances. The energy requirements for each of the first two were correlated on the basis of per-capita use with Gross Domestic Provincial Product (GDPP) per capita, energy prices, and a lag term. The form of the estimating equation has terms for income and price elasticity coupled with a lag parameter. The share that electricity will capture in these competitive heating markets was related to housing trends and the price of electricity relative to gas and/or oil. Electricity use for electric appliances was also correlated on a per-capita basis with GDPP per capita, electricity prices, and a lag term.

A similar approach was employed in the commercial sector, where energy use per service employee was correlated with GDPP and price.

Thus, the principal economic variables used in the model to forecast the demand for energy are:

- Gross Domestic Provincial Product (GDPP)
- Population
- Total employment
- Service employment
- GDPP/Manufacturing
- GDPP/Agriculture
- Production of the pulp and paper, chemical, steel, aluminum and mining industries.

The parameters used in the model are estimated on the basis of historical relationships. These parameters include income and price elasticities and lag parameters, market share parameters and gross economic parameters. These are listed and their use described in Appendix B. SRI have indicated that these parameters should be viewed as their best initial estimates for Ontario as a whole, and that they should be revised when increased understanding and knowledge of particular markets are obtained.

2.4.3 Scenarios Considered

The SRI-CEA model was used to project future growth in electric energy consumption for three scenarios in which the growth rate of the Ontario Gross Domestic Provincial Product (GDPP) was varied. The GDPP growth rates used and the resultant growth rates in electric energy consumption are shown in Figure 12 together with Ontario Hydro's 1978 forecast of peak growth rates. The SRI-CEA forecast of electric energy consumption is also shown graphically in Figure 13 for each scenario. The detailed output of the model for several years for each scenario is provided in Appendix C.

Scenario #1 is the reference forecast using the parameters suggested by SRI when they developed the model. The SRI reference forecast used rates of growth in GDPP of 3.8% to 1990 and 3.2% thereafter. The result is a forecast average annual growth rate in electric energy consumption to the year 2000 of 4.7%, somewhat lower than Ontario Hydro's 1978 forecast of peak load growth for eastern Ontario.

Scenario #2 illustrates the effect of using GDPP growth rates approximately the same as those published in December 1977 by the Ontario Economic Council (OEC)*. These rates are 5.3% per year to 1981, 4.4% per year to 1985 and 4.1% per year thereafter. These result in a forecast average annual growth rate in electric energy consumption to the year 2000 of 6.3%, somewhat higher than Ontario Hydro's 1978 forecast of peak load growth for eastern Ontario.

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*Ontario Economic Council Report, "The Ontario Economy 1978-1987", December 1977, J.A. Sawyer, D.P. Dungan and J.W.L. Winder.

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Scenario 3 illustrates the effects of high growth in which GDPP is assumed to grow at a rate of 5.5% until 1985 and at 4.5% thereafter. These result in a forecast average growth rate in electric energy consumption of 7.2% per year in the period to 2000.

The SRI-CEA model shows how the growth in electric energy consumption is dependent on the forecast of total economic activity in the province. It is also capable of examining the effects of changes in the other major variables on the consumption of electrical energy.

3.0 Existing Supply Facilities

3.1 General

The loads are supplied by transmitting bulk power to major supply stations near the load centres. This power is transmitted over a relatively few high capacity transmission lines from major generating stations in Ontario including some located in the Eastern Region. Most of the hydraulic generating capacity in the Region is located on the Madawaska, Ottawa, and St. Lawrence Rivers. Also, transfer of power may take place with Quebec and New York State in emergency conditions, in times of short-term shortages of resources, or when surplus power is available.

Figures 14 and 15 show the location of the major load supply stations, generating stations, and bulk power transmission lines in eastern Ontario. Bulk power received at major supply stations is typically stepped down in voltage and transmitted to distribution stations or to individual customers. Since this report is concerned with the supply of power in bulk to the major supply stations in the region, the low voltage distribution system is not shown.

3.2 Generation

As mentioned in Section 2.3, the supply of the Ottawa area is the most critical problem. The very large load in this area is mainly supplied by generation outside the area. There are some hydraulic plants in the area which supply a small part of Ottawa's power requirements. The January capacities of these plants for different water flow conditions are shown in the following table. The dependable values are those attained or exceeded in most years. The median values are those which have a probability of being attained or exceeded one year out of two. Design of the transmission to supply the Ottawa area is based on the dependable peak values.

Plant	Dependable Peak Capability (MW)	Dependable Average Capability (MW)	Median Peak Capability (MW)	Median Average Capability (MW)
Arnprior	78	6	78	13
Barrett Chute	172	13	172	28
Chats Falls	94	37	96	59
Stewartville	166	12	167	27
Total	510	68	513	127

In the above table, the difference between the normal peak capability available from the generating stations and the average power is large. Such plants are referred to as peaking plants. They are normally operated for only a few hours a day to coincide with the peak load periods in the day. During a large portion of the time, water is being stored so that it can be used in larger quantities during times of greatest system demand. There are significant economies associated with this type of operation because it reduces the amount of more costly thermal generation such as combustion turbines or older thermal units that must be run to satisfy the daily peak load demand.

During times of the day when the load is fairly high but the peaking hydraulic plants are shut down for water storage, power to replace their output is transmitted into the region over the bulk transmission system from the rest of the Ontario system.

Other hydraulic plants on the Ottawa River, namely, Chenaux GS, Des Joachims and Otto Holden GS; and Mountain Chute GS on the Madawaska River, do not supply power directly to the Ottawa area. Major new transmission would be required to reconnect this generation to the Ottawa area. In view of the relatively small amount of available capacity in these plants, that is the capacity after the local loads have been subtracted, and the small amount of undeveloped capacity on the Ottawa and Madawaska Rivers, such reconnection would not remove the need for new transmission from the main part of the bulk power system to Ottawa.

3.3 Power Purchases

Until recently some firm power was supplied to the Ottawa area under contract with Hydro-Quebec. That contract expired on May 31, 1977. Hydro-Quebec has advised that no firm power will be available to Ontario during heavy load periods up to 1985.

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Subject to in-service dates being met, surplus power will be available at other times in this period, and Ontario Hydro is actively pursuing these surpluses.

Continual discussion and studies are carried on with Hydro-Quebec regarding the possibility of the purchase or sale of firm power and energy. While it is possible that some firm power assistance from Hydro-Quebec might be available after 1985, there is considerable uncertainty about the availability and cost of such assistance. It would be unwise to proceed on the assumption that such assistance would remove the need for additional transmission to the Ottawa area.

The interconnection with the New York system in eastern Ontario is near Cornwall. Even if firm purchases could be arranged at that point, it would not relieve the problem of supplying the Ottawa load because of the transmission limitations discussed in section 5.

4.0 Criteria for Adequacy of the Ottawa Area Supply

The normal criterion for the assessment of the adequacy of supply facilities for an area such as the Ottawa area is that acceptable voltage and loading conditions must be maintained following the loss of the two most critical elements. An element is any major component of the system such as a transmission circuit, transformer, circuit breaker, etc. As will be shown later, the existing supply facilities for the Ottawa area will fail to meet this criterion in 1981. The lead times for new facilities, either generation or transmission, make it impractical to have facilities in service until much later than 1981. Therefore, the capability of the system has been assessed for a reduced criterion, under which acceptable conditions must be maintained following the loss of only one element. The assessment has been made for the following system conditions:

A. Load

The forecast peak load for the winter season under study.

B. Hydraulic Generation in the Ottawa Area

Hydraulic generation at peak output.
This is based on the assumption that the generation is operating at peak output at the time of the contingency or can be increased to that output quickly enough to avoid unacceptable conditions resulting from overloaded circuits.

The hydraulic generation in the Ottawa area is mainly located on the Madawaska River and is peaking generation. It is normally operated at peak output for only about 2 hours during the daily heavy load period, but there is sufficient water storage to permit operation in an emergency for several days at peak output.

C. Interconnection Loadings

The loadings on the circuits to Hydro-Quebec and to New York State in the Ottawa-Cornwall area are zero.

5.0 Adequacy of Existing Facilities

5.1 General

As discussed in section 4, the use of reduced criteria to assess the required facilities to supply the Ottawa area load will lower the reliability of supply to that load in the early 1980's. We believe that this reliability will be further reduced because of the need for a number of stop-gap measures. These are required in order to enable the supply system to meet the forecast load, even using the reduced criteria, in the period up to about 1986 when it is estimated new facilities could be placed in service. The planned stop-gap measures include work such as large increases in circuit ampacities and the installation of large amounts of static capacitors or other types of reactive power sources. They involve, on an extensive basis, a major extrapolation of present practices, and this could introduce unexpected problems. The planned stop-gap measures are discussed in more detail in the following sections.

5.2 Transmission Capacity

The most important circuits of the existing bulk power transmission system in eastern Ontario are shown in Figure 16. The circuit capacities are indicated. Many of these circuits would be overloaded soon, but it is planned to increase their capacity in one or more of the ways discussed below:

A. High Temperature Operation

Aluminum cable steel reinforced (acsr) transmission line conductors have usually been operated at temperatures of up to 90° C in normal conditions and up to 125° C in emergency

conditions. Ontario Hydro has carried out extensive field and laboratory tests to determine the practicality of operating the existing acsr conductors at higher temperatures or replacing them with conductors which can be operated at higher temperatures. These tests have indicated that operating temperatures of up to 150° C are permissible. This is a considerable increase over past practice and significantly higher than used by other utilities. For example, a 1977 report* by a CIGRE Study Committee of utility practice in Germany, England, Ireland, France, Belgium, Sweden and Hungary indicated that maximum conductor temperatures for emergency operation range from 50°C to 110°C with most of the values being either 75°C or 80°C. In order to allow for the increased conductor sag at these higher temperatures, it is required in most cases that the tension of the conductors be increased or that the conductors be raised by adding extensions to the existing towers.

B. <u>Replacement of Conductors</u>

In some cases additional capacity can be obtained by replacing the existing conductor by a conductor with a larger aluminum cross-section where the structural design of the existing towers will permit. In some of these cases, in order to get the maximum ampacity, a new design of conductor is being used with less testing than would normally be required.

The work which it is practicable to do on each of the existing circuits has been determined by a detailed study of the individual circuits. Shown in Figure 17, for each of the most critical circuits in eastern Ontario, is the proposed capacity after the completion, of stop-gap work. Although it is considered acceptable to operate the existing circuits at the temperatures required to provide the capacities shown in Figure 17, there has been very little experience in the industry with such temperatures. Therefore, unexpected troubles could occur in service, and it must be accepted that the circuits will likely be less reliable than when operated more conservatively. A similar observation can be made about the structural security of the transmission line towers. When they have been restrung with conductors having a higher capacity, their structural capability will still exceed the minimum loading standards of the Canadian Standards Association, but there will be less reserve capability than now exists to withstand severe storm conditions which may occur, although infrequently.

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*CIGRE Committee, Working Group 31-02, Report Number 3177 (GT02) 01.

5.3 System Capability

Based on the capacities shown in Figure 17, and the reduced criteria, both discussed above, the capability of the existing system to supply eastern Ontario loads and in particular the Ottawa area has been examined.

The type of element most likely to be forced out of service is a transmission circuit. Transmission circuits comprise many components, such as insulators, conductors, towers, and terminal equipment such as circuit breakers, disconnecting switches, instrument transformers, protective relays etc. The failure of any one of these can cause the circuit to be removed from service automatically. Depending on the type of failure, the outage can last for periods of time ranging from a fraction of a second to several days. The three most critical links in this supply are the following 230 kV single circuit lines, the locations of which can be seen in Figure 14:

1. Circuit L24A from St. Lawrence TS to Hawthorne TS.

2. Circuit B31L/B5D/D5A from St. Lawrence TS to the Interprovincial Boundary to St. Isidore TS to Hawthorne TS.

3. Circuit C3S/M32S from Chats Falls GS to South March TS to Merivale TS.

The problem with these three links is that they will be loaded heavily by 1987 even with all circuits in service, and should one be removed from service because of an emergency, one or both of the remaining two would become overloaded. This would mean that if new facilties were not available by 1987 and the emergency occurred, sufficient load would have to be interrupted to keep the circuits within their ratings. The performance record for these three circuits for the periods from 1969 to 1971 and 1973 to 1977 inclusive is shown below:

Duration	Number of Outages 1969-1971 and 1973-1977 Inclusive		
	L24A	B31L/B5D/D5A	C3S/M32S
1 Minute or Less	11	16	7
1 to 5 Minutes	2	10	7
More than Five Minutes	5	58	8
Total Number of Outages	18	84	22
Average Duration (hours)	4.2	3.4	2.4
Average number of outages per year	2.3	10.5	2.8

The remaining 230 kV circuit into the Ottawa area, M29C from Merivale to Cherrywood TS, being a long circuit connected to a remote source, does not overload to the same extent.

The capability of the existing transmission facilities to supply the Ottawa-area load is indicated in Figure 18. The sloping line represents the forecast of load for the Ottawa area. As discussed below, the three horizontal lines on the figure show the capability for the three levels of criteria.

A. Normal Criteria

Figure 18 indicates that under normal criteria the existing facilities will not be adequate to supply the forecast Ottawa-area peak load in the winter of 1980/1981 and later. The outage of two critical circuits at the time of forecast peak load would cause overloads to occur, and load in the Ottawa-area would have to be reduced to remove these overloads. The amount of load reduction which would have to be made can be determined approximately from the figure as the difference between the horizontal line for the normal-criteria capability and the load curve. For example, in January, 1983 the required reduction would be about 200 MW.

B. Reduced Criteria

Under the reduced criteria, the existing facilities could supply the Ottawa-area forecast peak load in the winter of 1986/1987. Beyond that time, the outage of one of the critical circuits at the time of forecast peak load would cause overloads to occur, and load would have to be reduced to remove the overloads. The reduction would have to be made quickly, and therefore there would be no opportunity to forewarn customers. The reduction would be required until the faulted circuit was returned to service or the demand reduced with time. For example, the amount of load reduction which would have to be made in January, 1989 would be about 150 MW.

C. All Facilities in Service

The existing facilities could supply the Ottawa-area forecast load in the winter of 1990/1991 with all facilities in service, if no allowance is made for any contingencies. However, beyond that time, a load reduction would be required at times of heavy load even with all transmission facilities in service. For example, the amount of reduction which would have to be made in January 1993 would be about 250 MW.

It is important to note that the necessity to reduce load does not occur only at the time of peak load. There would be a significant number of hours in the year during which the load would be heavy enough to exceed the capability and still require load reduction, albeit of a smaller amount. For example, if in 1986 two circuits were out of service, the system would have the capability, indicated by the normal-criteria line, to supply an Ottawa-area load of about 1300 MW. An indication of the duration of load reductions that would be necessary can be obtained from Figure 19 which shows the number of hours in the year that the load is at various levels above the 1300 MW level.

The estimated conditions in eastern Ontario at the time of forecast peak loads in January 1987 are shown in detail in Figures 20 to 23. These figures show the results of computer-simulation of the system for various conditions. Shown are the power flows for each circuit and the voltages at each station.

Figure 20 indicates the normal conditions with all circuits in service.

Figure 21 shows the condition with one circuit, Chats Falls x South March (C3S) out of service. The St. Lawrence x Hawthorne circuit (L24A) is carrying about 2000 amperes, compared to a proposed capacity of 2500 amperes.

Figure 22 indicates the condition with the St. Lawrence x Hawthorne circuit (L24A) out of service. The St. Lawrence x Interprovincial Boundary x St. Isidore Circuit (B31L/B5D) is carrying about 1500 amperes, and the Chats Falls x South March circuit (C3S) is carrying about 1930 amperes, very close to its maximum capacity of 2040 amperes.

Figure 23 shows the conditions with the B31L/B5D circuit out of service. Circuits L24A and C3S are both heavily loaded, but not as close to their maximum ampacity as in the other emergency cases.

The conditions discussed above are for the forecast load, which is the most probable value of load. If the load growth rate were to be higher than this forecast amount, the existing facilities would be inadequate sooner, and if the rate were to be lower, the reverse would be true. This is illustrated in Figure 24 in which a high and a low forecast (average annual growth rates of about 7% and 4% respectively) have been superimposed on Figure 18. This shows that based on reduced criteria, new facilities would be required for the high and low forecasts in 1985 and 1995 respectively rather than in 1987 for the forecast load.

5.4 Requirement for Reactive Power Sources

The capability discussed above is based on the assumption that static capacitors or other types of reactive power sources would be installed as required to maintain adequate voltages for normal and emergency conditions. Heavier loadings on the existing circuits increase the amount of reactive power sources required. Static capacitors are estimated to cost about $8200 per Mvar (1979$) to install. Other types of reactive power sources which may be required to solve voltage control problems would be considerably more costly. The type of source to use is still under investigation. Figure 25 shows an estimate of the total amount of reactive power sources required, in addition to the amount existing in 1978, for the period up to January 1987. This is the amount that would be required for emergency conditions in which one circuit is out of service and if no major transmission facilties were added. For example, in 1986, it would be necessary to install about 300 Mvar for a total addition of about 1250 Mvar, required for the winter peak load of 1986/1987.

It will be necessary that some of the static capacitors be switched automatically when some of the key 230 kV lines are switched out because of a line fault or other cause. It will be essential that this switching operate correctly to prevent excessive voltage drop or a complete collapse. While such installations are not new to the industry, the extent of the planned installations are far in excess of any installations that we know of.

5.5 Transmission Power Losses

Another important aspect of a heavily loaded system in eastern Ontario is an increase in transmission losses. Figure 26 shows the estimated maximum bulk power transmission losses for the Eastern Region for each year, and indicates that by January, 1987 they would amount to about 245 MW. By January, 1988 these losses would be equal to about 280 MW, or about 15% of the annual load growth. The 1988 losses could be reduced by as much as 145 MW by the addition of new bulk power facilities, and the value of this saving is estimated to be about eighteen million dollars per year (1988$). This estimate is based on the cost of the energy to replace the losses, and does not include capacity charges.

6.0 Conclusions

The earliest possible time by which major new bulk power transmission facilities could be installed to increase the power supply to the Ottawa area is 1986. Planning should therefore proceed now to enable new facilities to be placed in service as expeditiously as possible for the following reasons:

A. If the load grows at the forecast rate, the reliability of supply will be less than desirable in 1981 and subsequent years up to the in-service date of major new facilities. If major new facilities are not installed by 1987, the reliability will be extremely poor and it will be necessary to automatically reduce load if one of the critical circuits is forced out of service in a heavy-load period.

B. By 1988, new facilities could reduce the power losses in supplying the Ottawa-area load by about 145 MW. The decreased losses would be equivalent to a reduction in system load, and therefore, would effectively increase the system load-meeting capability.

C. The annual cost of the bulk power transmission losses will increase rapidly. It is estimated that the saving in losses in 1988 by the addition of new bulk power facilities could be as much as $18,000,000 ($1988) considering energy costs only and including no capacity charges.

D. If the load growth proves to be greater than the forecast amount, the need for the facilities will be even more pressing. However, it is impractical to speed up the process of obtaining approvals, acquiring property rights and constructing new facilities. On the other hand if the load growth proves to be less than forecast, it would be possible to delay construction if considered desirable.

E. The bulk of the expenditures for major new facilities required for service in 1986 would not have to be committed until 1982, at which time the factors outlined above will be reviewed and a final decision made as to the timing of the new facilities. However, if the option of having the facilities in service by 1986 is to be retained, the process now under way, of studying alternatives, selecting a plan and specific locations for facilities must continue. In other words, for several years ahead, the project can be cancelled or deferred without incurring any loss except for the cost of the ongoing studies.

APPENDIX A

Copy of Order-in-Council Document

OC-2065/78, dated July 12, 1978.

Ontario

Executive Council

O.C. 2065/78

Copy of an Order-in-Council approved by Her Honour the Lieutenant Governor, dated the 12th day of July, A.D. 1978.

The Committee of Council have had under consideration the report of the Honourable the Provincial Secretary for Resources Development, wherein he states that,

WHEREAS the Royal Commission on Electric Power Planning was appointed pursuant to The Public Inquiries Act, 1971, and its terms of reference were established by Order-in-Council numbered OC-2005B/75 dated 17th July, 1975;

AND WHEREAS paragraph 4 of Order-in-Council numbered OC-2005B/75 called for the Commission to consider and report on certain projects on a priority basis;

AND WHEREAS by Order-in-Council numbered OC-3489/77 the Royal Commission on Electric Power Planning was requested to provide its interim report on issues relating to nuclear power in Ontario by June 30, 1978;

AND WHEREAS since July, 1975, revisions have been made in the projections of electric load growth expected to occur in Ontario Hydro's East System before 1988, and beyond that date to the year 2000;

AND WHEREAS, in part as the result of such load growth revisions for the period beyond 1987, it is no longer necessary for the Royal Commission to

consider and report on a priority basis on the North Channel generating station;

AND WHEREAS in light of the passage of The Environmental Assessment Act, 1975, which followed the approval of the Royal Commission's terms of reference, the description of specific transmission connections set out in paragraph 4 of the terms of reference is no longer appropriate and should be replaced by an examination of the need for, and the timing of, additional bulk power facilities within broad geographic areas;

AND WHEREAS it is desirable to have the Royal Commission on Electric Power Planning review the need for, and the timing of, additional bulk power facilities and to report thereon to the Ministry of Energy, and for the specific nature of additional bulk power facilities which might then be proposed, including their locational and environmental aspects, to be reviewed by the Environmental Assessment Board;

AND WHEREAS the Government further intends to appoint members of the Royal Commission on Electric Power Planning to the Environmental Assessment Board in order to transfer experience in electric power planning matters to that Board;

AND WHEREAS by Order-in-Council numbered OC-1999/78 dated the 5th day of July, 1978, the Committee of Council amended paragraph 4 of the Commission's terms of reference,

AND WHEREAS a paragraph was omitted from Order-in-Council numbered OC-1999/78, rendering it incomplete,

The Honourable the Provincial Secretary for Resources Development recommends that Order-in-Council numbered OC-1999/78 be revoked and that paragraph 4 of Order-in-Council numbered OC-2005B/75 be further amended as follows:

4.) A) Having concluded its hearings with respect to paragraphs 1, 2 and 3 of its terms of reference;

i) For the geographic area of Ontario south of Bruce nuclear power development and west of a line between Essa transformer station and Nanticoke generating station, consider and report to the Minister of Energy on or before May 31, 1979 on load growth in the area up to the end of 1987 and from 1987 to the year 2000, the capability of existing and committed bulk power generation and transmission facilities to supply this load to the area taking into account Government policy with respect to the use of interconnections with neighbouring utilities, and the resulting date at which additional bulk power facilities, if any, will be needed, but excluding consideration of the specific nature of the additional bulk power facilities which may be required and of their locational and environmental aspects; and

ii) For the geographic area of Ontario east of Lennox generating station, consider and report to the Minister of Energy on or before June 30, 1979 on load growth in the area up to the end of 1987 and from 1987 to the year 2000, the capability of existing and committed bulk power generation and transmission facilities to supply this load to the area taking into account Government policy with respect to the use of interconnections with neighbouring utilities, and the resulting date at which additional bulk power facilities, if any, will be needed, but excluding consideration of the specific nature of the additional bulk power facilities which may be required and of their locational and environmental aspects;

B) Provide the Government with its report and recommendations on paragraphs 1, 2 and 3 of these terms of reference on or before October 31, 1979.

The Committee of Council concur in the

recommendation of the Honourable the Provincial Secretary for Resources Development and advise that the same be acted on.

Certified,

J Lewis

Deputy Clerk, Executive Council.

APPENDIX B

Chapter III and Tables B-7 and B-8 from the SRI Report to CEA Entitled "Long Range Electricity Forecast for Canada - A Methodology", dated November, 1978.

III MODEL RELATIONSHIPS

Four types of forecasting equations were developed: one for the industrial market, one for the residential and commercial markets, one for the farm sector, and one for competitive heating markets. These relationships along with general macroeconomic model relationships are discussed in Chapter III. The specific equations are listed in Appendix A. Descriptions of the various methods employed in the estimation of model parameters are detailed in Appendix B.

General Energy Growth and Market Share Model

This section serves as a discussion of the concepts and implementation of the model for all of the energy markets described in the study, except for the farm market, which has its own equation form. (Its form will be described later.) The general approach to describing total market growth will be outlined, followed by a discussion of exactly which variables control the model equation for each end-use market. This discussion will be referenced in each of the market sections that follow in Chapter IV of this report. In addition, for those markets in which electricity competes with other fuels, we discuss the methodology that connects market share and electricity demand.

In general terms, the model equation used in this study is as follows:

$$\begin{gathered}
\text{(Demand in the next period)} = \\
\text{Constant} \times \text{(Demand in the current period)}^{\alpha} \times \\
\text{(Income in the next period)}^{A(1-\alpha)} \times \\
\text{(Price in the next period)}^{B(1-\alpha)} .
\end{gathered}$$

The first term in the form, the constant, is simply a statistical requirement for fitting historical data. In the actual implementation of the form, the constant is not relevant as a ratio form is used to force the model to extrapolate from the last year in the historical period. The ratio form has the following appearance:

$$\frac{\text{Demand in the next period}}{\text{Demand in the current period}} =$$

$$\left(\frac{\text{Demand in the current period}}{\text{Demand in the previous period}}\right)^{\alpha} \times$$

$$\left(\frac{\text{Income in the next period}}{\text{Income in the current period}}\right)^{A(1-\alpha)} \times$$

$$\left(\frac{\text{Price in the next period}}{\text{Price in the current period}}\right)^{B(1-\alpha)}$$

The exponents of the ratio form are identical to the non-ratio form. The second term of the original form is the lag term, and the exponent α is the lag parameter. The interpretation of this parameter is that the next period depends to some extent on the current period. Another way to look at it is to consider there is a certain amount of inertia in each market. Regardless of the economic influences of the next period--the income and price terms--total market consumption can only increase or decrease so much. With appliances, for example, limited electricity distribution and possible limitations in the availability of appliances could hold down the growth of the market despite sharp increases in income and drops in electricity prices. The term α measures the magnitude of this inertia in each market. In one extreme case, $\alpha = 1$ means that the market is fixed at a constant value and is not sensitive at all to economic influences. In the other extreme case, $\alpha = 0$ means that there is no inertia and that the market depends only upon economic influences. Real-world situations, of course, fall between these two extremes.

Two energy markets represent the extremes of this lag and time response. In one extreme, manufacturing facilities, energy use tracks levels of plant production. In this case there is no time lag; therefore, the lag parameter is zero. Another case is the conversion of households to electric heating, a more slowly-moving market. The lag parameter would be more like 0.95, reflecting the 25 or more years required to convert all households. Table 5 lists values of the lag parameter and the corresponding time in years for an 80 percent change in the market in response to a given occurrence.

Table 5

RELATIONSHIP BETWEEN LAG PARAMETERS AND TIME

Lag Parameter	Time (years)
0.0	0.0
0.2	1.2
0.4	1.8
0.6	3.2
0.8	7.2
0.9	15.0

The third term stands for income, and reflects the notion that the more people make, the more energy they consume. There is, however, a saturation effect. People will keep their homes only so warm or buy only so many appliances, regardless of their income. Saturation terms can be explicitly included in the model, but limitations in the data, as well as a preference for simplicity, have led us not to do so. The system does allow for considering saturation effects through its ability to vary parameters with time throughout the forecast horizon.

The exponent of the income term is $A(1-\alpha)$, where A represents the long-term income elasticity, and the $(1-\alpha)$ adjusts for the lag parameter. Only $(1-\alpha)$ of the "frictionless" income effect will occur because of the inertia that is described by the lag term. The significance of income elasticity might be seen most easily in the ratio form. It measures how much of a relative change in energy consumption will result from a given

relative change in incomes. Typical values for A are about 0 to 0.2 for heating markets, about 0.9 to 1.2 for light manufacturing, and more than 1.0 for appliances and the commercial end uses.

The last term stands for price. B represents the price elasticity, and (1-α) stands for the same lag adjustment as above. The same comments about saturation that were made previously also apply to the price term. The ratio form, given that B must be negative, shows that the price elasticity controls the relative market growth in response to a given relative reduction in price. The inverse effect of the elasticities also naturally applies; falling incomes and rising prices lead to shrinking markets.

Given the general form, it still remains to select exactly those variables that are to be used to model each market. The choices include the following:

- Total energy consumption (demand) or consumption (demand) per capita
- The measure of income most closely related to a given market
- The appropriate measure of price.

Table 6 shows the variables chosen to describe each energy market. The weighted average prices previously specified are calculated using the oil, gas, and electricity market shares and their respective prices. Although all prices are forecast, only electricity's market share is forecast for the competitive markets. The market shares of oil and gas in the base year are used for the purposes of calculating the weighted averages, both for the energy relationships and the market share projections. Trial calculations demonstrated that this simplification introduced negligible error into the results.

Farm Forecasting Relationship

The special equation for electrical energy consumption on farms is slightly different from the equations for the other market relationships. While more detailed work is needed on the agricultural sector, the relationship included in the model captures the following concepts of what controls the market:

Table 6

MODEL VARIABLES

Market	Energy Measure	Income Measure	Price Measure
Residential space heating	kWh/capita	Total GDPP/ capita	Weighted average residential energy price
Residential water heating	kWh/capita	Total GDPP/ capita	Weighted average residential energy price
Appliances	kWh/capita	Total GDPP/ capita	Residential electricity price
Commercial heating	kWh/service employee	Total GDPP/ capita	Weighted average residential energy price
Commercial motors	kWh/service employee	Total GDPP/ capita	Commercial electricity price
Street lighting	kWh	Total GDPP	Commercial electricity price
Light manufacturing	kWh	GDPP-Manufacturing	Industrial electricity price

- There is a lagged relationship between energy requirements and GDPP-Agriculture.
- There is a strong relationship between farm usage and general residential usage in the same period.

The following parameters are specified for the farm equation:

A: The GDPP-Agriculture elasticity

B: The total residential consumption electricity

C: The GDPP-Agriculture lag factor.

A specifies the relative growth of agricultural electricity demand compared to the growth in GDPP-Agriculture. B specifies the amount of relative growth dependent on residential demand growth. C is the familiar lag factor.

Industrial Forecasting Relationships

All of the industrial sector markets, except light manufacturing, are forecast using a straightforward approach. Electricity consumption for light manufacturing is forecast based on GDPP-Manufacturing and industrial price for electricity, as described previously. The rest of the markets are estimated as follows:

(1) The data for the base year of history are used to calculate the electricity consumption per unit of industrial output.

(2) The annual growth rate of industrial output, supplied by the user, is used to project the output.

(3) The parameter for annual efficiency improvement is used to reduce the expected electrical consumption per unit of output.

(4) The expected output is multiplied by the expected per unit consumption to yield total consumption by industry.

The annual efficiency improvement estimates should be based both on experience and on available technological forecasts. The form of the average improvement equation is:

$$\text{(Unit usage next period)} = \left[\frac{\text{(Units consumed during last period)}}{\text{1 + Efficiency improvement}}\right] .$$

Market Share Forecasts

The principal markets in which electricity competes with other sources of energy are the residential space heating, residential water heating, and commercial heating markets. For these markets, SRI's approach is first to estimate the total energy requirements and then to estimate the share of the market that will be captured by electricity.

The form of the market share model can be described in two parts. In the first stage,

(Market share in the next period) =
(Lag factor) x (Market share in the next period) +
(1 - lag factor) x (Expected market share) .

The lag factor has much the same significance here as it did in the energy equations: market share can change only so much from period to period because of lags in the economy. The expected market share indicates what the market share would be if there were no lags in the system, i.e., what share a given fuel--electricity in this case--would be based on theoretical economic considerations. Another way to look at market share would be to consider it as what the market share would be in many years if there were no changes in economic conditions.

The second stage, the long-term expected market share, is calculated as follows:

$$\text{(Expected market share)}_e = \frac{\text{(Maximum market share)}}{\left(1 + P_R^N\right)}$$

$$\text{where } P_R = \frac{(\text{Price}_e)\ (\text{Efficiency})}{\left(\text{Price}_{avg}\right)} .$$

The maximum market share term is included for situations when it is known that, for other reasons--distribution problems, for example--a given fuel will never capture all of a market regardless of the price incentives. The form of the equation is such that even if the price of the fuel in question reaches zero, the resulting market share will never rise above the maximum market share.

The term $\frac{\text{Price}_e}{\text{Price}_{avg}}$ measures the relative price incentive of using electricity. Price_{avg} is the average price of competing fuels, weighted by market share. For a given set of parameters, it can be seen as Price_e, the price of electricity drops, the resulting market share approaches the maximum market share.

The efficiency parameter provides for the adjustment of the results to account for such differences as the capital requirements needed to convert from one fuel to another, and societal or consumer preferences for one fuel versus another. One way to develop a fuel efficiency value

is to consider a price ratio that, all things considered, would lead to a fuel's capturing half of the maximum market share.

GDPP and Population Forecasts

Two key parameters that are supplied by the user are the growth rates for GDPP and GDPP per capita. The specifications of these two rates imply a growth rate for population that is calculated by the system. It would have been possible to input any two of these three growth rates and calculate the third. Total GDPP and GDPP per capita were chosen because the first reflects total growth in the provincial economy and the second suggests individual economic well-being. The calculated population growth rate, meanwhile, is the maximum sustainable growth rate consistent with the projected gains in economic activity and improvements in the standard of living.

It has been shown that several other key macroeconomic variables can be projected based on these growth rates. (Examples are included in the statistical summary in Appendix B). The method used in this system is to specify the relationship--a kind of elasticity--between the controlling growth rate and the dependent growth rate. Five such elasticities are used in the system:

(1) GDPP-Manufacturing, based on total GDPP
(2) GDPP-Agriculture, based on total GDPP
(3) Total employment, based on population
(4) Service employment, based on population
(5) Number of households, based on population.

In Ontario, for example, the elasticity of service employment with population was specified as 2.4 in 1976, dropping to 2.2 in 1990. That means that service employment is expected to grow 2.4 times as fast as population, dropping to 2.2 times as fast later. These variables, with the exception of number of households and total employment which are calculated for informational purposes, are used in subsequent calculations. The number for service employment, for example, is used to derive the data on energy consumption per service employee; this input is used in

the models that deal with electricity use for motor drives and heating in the commercial market.

TABLE B-7
FORECAST MARKET SHARE AND PRICE PARAMETERS

MARKET SHARE MODEL	ONTARIO 1976	ONTARIO 1990
RESIDENTIAL SPACE HEATING		
Lag Parameter	.91	.91
Max. Share	100.0	100.0
Relative El. Efficiency	50.0	50.0
Price Ratio Power	2.83	2.83
RESIDENTIAL WATER HEATING		
Lag Parameter	.80	.80
Max. Share	100.0	100.0
Relative El. Efficiency	80.0	80.0
Price Ratio	.10	.10
COMMERCIAL SPACE HEATING		
Lag Parameter	.95	.95
Max. Share	100.0	100.0
Relative El. Efficiency	50.00	50.00
Price Ratio Power	2.00	2.00
PRICE GROWTH RATES REAL		
Residential		
Electricity	1.00	1.00
Gas	2.00	2.00
Oil	0.00	2.00
Commercial		
Electricity	2.00	1.00
Gas	3.00	2.00
Oil	0.00	2.00
Industrial		
Electricity	2.00	1.00

TABLE B-8
REFERENCE CASE FORECAST
MACROECONOMIC AND INDUSTRIAL PARAMETERS

MACRO GROWTH RATES	ONTARIO 1976	ONTARIO 1990
GDPP	3.8	3.2
GDPP/Capita	2.4	2.0
Population	1.4	1.2
CPI Percent/Year	6.0	4.0
ELASTICITIES		
GDPP Mfg./GDPP	.90	.85
GDPP Ag./GDPP	.40	.40
Total Employment/Pop.	1.8	1.4
Serv. Employment/Pop.	2.4	2.2
Households/Pop.	1.8	1.6
INDUSTRIAL GROWTH RATES		
Aluminum	3.5	2.5
Pulp & Paper	3.0	2.0
Chemicals	4.5	3.5
Steel	3.0	2.5
INDUSTRIAL EFFICIENCY IMPROVEMENTS PERCENT/YR.		
Aluminum	.50	.50
Pulp & Paper	.50	.50
Chemicals	.50	.50
Steel	.50	.50
MINING GROWTH RATES		
Iron Ore	3.0	2.5
Copper	3.0	2.0
Coal	6.0	3.0
Other	5.0	4.0
MINING EFFICIENCY IMPROVEMENTS		
Iron Ore	0.0	0.0
Copper	0.0	0.0
Coal	0.0	0.0
Other	0.0	0.0
LOSSES AND EXPORTS	9.60	9.60

APPENDIX C

Results from SRI-CEA Model Study in which the Growth Rates of Gross Domestic Provincial Product Were Varied.

EASTERN ONTARIO
FORECAST OF ELECTRIC ENERGY CONSUMPTION
USING SRI-CEA ECONOMETRIC MODEL

SCENARIO 1
BASIS: All Parameters Including GDPP as in SRI-CEA Model Reference Forecast

	ELECTRIC ENERGY CONSUMPTION (GW·h)					
	Actual	Forecast				
	1976	1980	1985	1990	1995	2000
RESIDENTIAL (GW·h)						
SPACE HEATING	469	757	1045	1280	1508	1766
WATER HEATING	1150	901	810	815	849	899
APPLIANCES ETC.	958	1148	1420	1736	2013	2333
TOTAL RESIDENTIAL ELECTRICITY	2577	2807	3274	3831	4370	4998
TOTAL FARM (GW·h)	289	315	365	423	479	543
COMMERCIAL (GW·h)						
HEATING	193	847	1750	2743	3805	5030
OTHER (MOTORS + LIGHTING)	3143	4034	5423	7032	8567	10432
STREET LIGHTING	60	71	87	106	123	142
TOTAL COMMERCIAL ELECTRICITY	3396	4952	7260	9881	12494	15605
MANUFACTURING (GW·h)						
PULP + PAPER	271	299	338	379	408	439
CHEMICALS	421	492	598	720	834	966
STEEL	0	0	0	0	0	0
LIGHT MANUFACTURING	1441	1645	1940	2270	2570	2910
TOTAL MANUFACTURING	2133	2436	2876	3368	3812	4315
MINING (GW·h)	0	0	0	0	0	0
TOTAL CONSUMPTION (GW·h)	8395	10510	13775	17503	21155	25460

EASTERN ONTARIO
FORECAST OF ELECTRIC ENERGY CONSUMPTION
USING SRI-CEA ECONOMETRIC MODEL

SCENARIO 2

BASIS: Growth Rates in GDPP as per Ontario Economic Council
All Other Parameters as in Scenario 1.

	ELECTRIC ENERGY CONSUMPTION (GW·h)					
	Actual	Forecast				
	1976	1980	1985	1990	1995	2000
RESIDENTIAL (GW·h)						
SPACE HEATING	469	802	1148	1436	1767	2161
WATER HEATING	1150	955	891	914	995	1100
APPLIANCES ETC.	958	1216	1561	1948	2359	2855
TOTAL RESIDENTIAL ELECTRICITY	2577	2973	3600	4298	5121	6116
TOTAL FARM (GW·h)	289	332	398	470	554	654
COMMERCIAL (GW·h)						
HEATING	193	968	2184	3584	5459	7927
OTHER (MOTORS + LIGHTING)	3143	4612	6767	9187	12292	16440
STREET LIGHTING	60	76	98	121	147	178
TOTAL COMMERCIAL ELECTRICITY	3396	5656	9048	12893	17899	24545
MANUFACTURING (GW·h)						
PULP + PAPER	271	299	338	379	408	439
CHEMICALS	421	492	598	720	834	966
STEEL	0	0	0	0	0	0
LIGHT MANUFACTURING	1441	1741	2132	2541	2986	3509
TOTAL MANUFACTURING	2133	2532	3068	3640	4228	4914
MINING (GW·h)	0	0	0	0	0	0
TOTAL CONSUMPTION (GW·h)	8395	11494	16114	21301	27802	36229

EASTERN ONTARIO
FORECAST OF ELECTRIC ENERGY CONSUMPTION
USING SRI-CEA ECONOMETRIC MODEL

SCENARIO 3

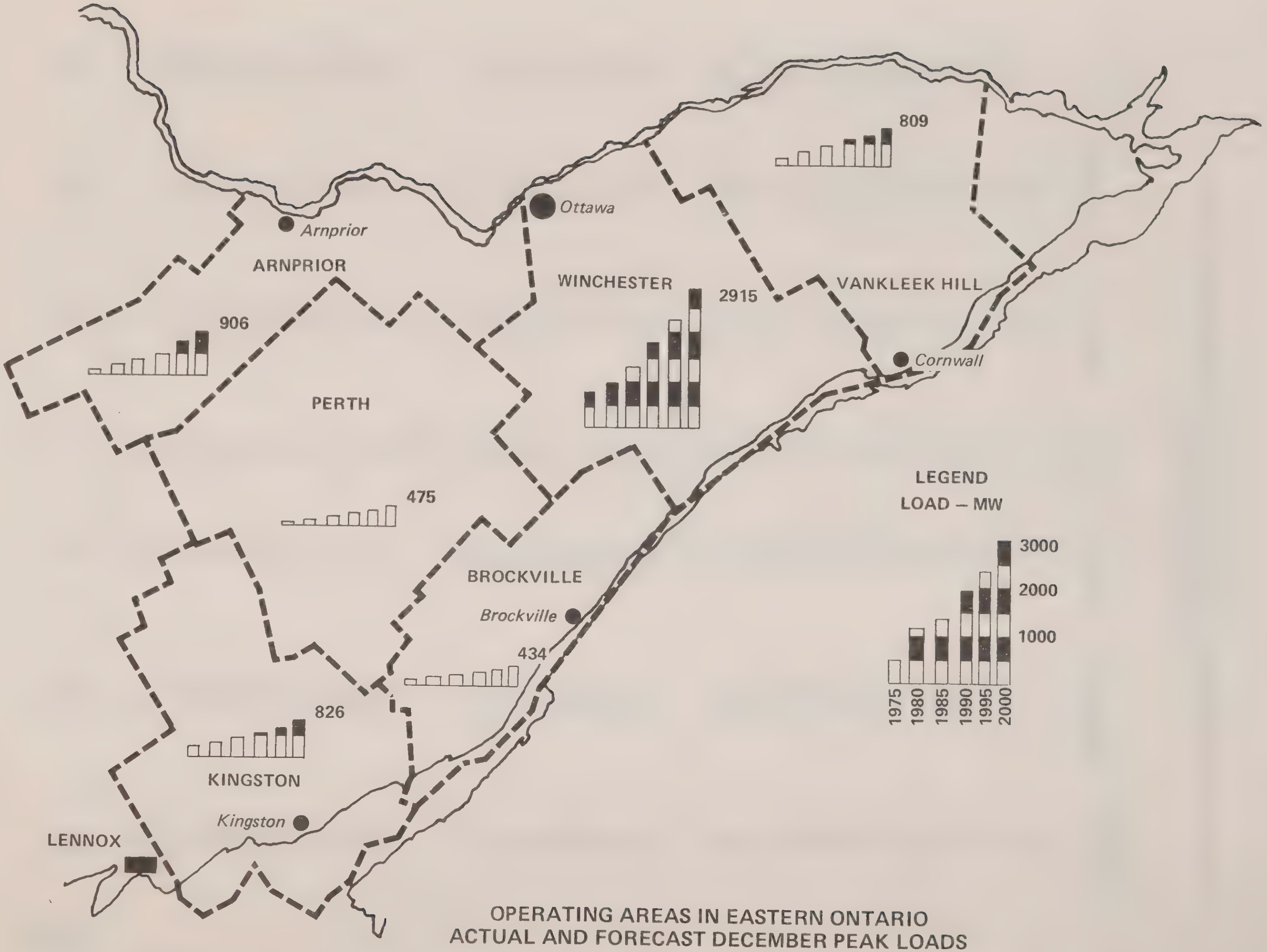
BASIS: High Growth Rates in GDPP;
All other Parameters as in Scenario 1

	ELECTRIC ENERGY CONSUMPTION (GW·h)					
	Actual	Forecast				
	1976	1980	1985	1990	1995	2000
RESIDENTIAL (GW·h)						
SPACE HEATING	469	808	1209	1541	1933	2409
WATER HEATING	1150	962	938	981	1088	1226
APPLIANCES ETC.	958	1225	1643	2090	2581	3184
TOTAL RESIDENTIAL ELECTRICITY	2577	2995	3790	4613	5602	6819
TOTAL FARM (GW·h)	289	335	417	502	602	723
COMMERCIAL (GW·h)						
HEATING	193	985	2460	4220	6698	10133
OTHER (MOTORS + LIGHTING)	3143	4694	7624	10817	15080	21015
STREET LIGHTING	60	77	103	132	163	201
TOTAL COMMERCIAL ELECTRICITY	3396	5756	10187	15170	21941	31348
MANUFACTURING (GW·h)						
PULP + PAPER	271	299	338	379	408	439
CHEMICALS	421	492	598	720	834	966
STEEL	0	0	0	0	0	0
LIGHT MANUFACTURING	1441	1754	2243	2725	3255	3888
TOTAL MANUFACTURING	2133	2545	3180	3823	4497	5293
MINING (GW·h)	0	0	0	0	0	0
TOTAL CONSUMPTION (GW·h)	8395	11631	17574	24107	32641	44184

ACTUAL AND FORECAST SUM OF CUSTOMER DECEMBER PEAK LOADS BY OPERATING AREAS
MW

	VANKLEEK HILL	WINCHESTER	ARNPRIOR	PERTH	BROCKVILLE	KINGSTON	TOTAL
				ACTUAL			
1962	131	274	8	31	89	122	655
1963	126	289	8	32	84	120	659
1964	116	281	41	34	84	145	701
1965	117	312	49	36	84	155	753
1966	127	352	72	42	92	156	841
1967	128	384	81	44	91	162	890
1968	138	470	95	50	102	174	1029
1969	142	489	106	55	107	176	1075
1970	147	532	122	64	107	197	1169
1971	151	572	127	65	108	203	1226
1972	160	625	141	70	118	222	1336
1973	171	662	150	76	122	244	1425
1974	170	681	158	71	119	239	1438
1975	175	780	183	92	138	261	1629
1976	252	823	196	99	143	280	1793
1977	253	812	198	97	148	278	1786
				FORECAST – 780213			
1978	265	844	210	105	151	282	1857
1979	279	893	225	115	159	298	1969
1980	303	948	240	125	166	310	2092
1981	320	1006	256	138	174	324	2218
1982	343	1074	275	152	184	343	2371
1983	366	1144	295	167	194	360	2526
1984	391	1218	316	185	205	378	2693
1985	417	1297	340	205	216	397	2872
1986	446	1381	365	227	228	417	3064
1987	478	1470	392	251	241	438	3270
				PROJECTION			
1988	498	1550	421	265	253	461	3448
1989	519	1635	452	279	266	485	3636
1990	541	1724	484	294	279	510	3832
1991	564	1818	518	309	293	536	4038
1992	587	1916	554	325	307	563	4252
1993	611	2020	591	341	321	591	4475
1994	636	2130	631	359	336	621	4713
1995	662	2245	672	376	351	652	4958
1996	689	2366	715	395	367	684	5216
1997	717	2493	760	414	383	717	5484
1998	747	2627	807	433	399	752	5765
1999	777	2768	855	454	416	788	6058
2000	809	2915	906	475	434	826	6365
				GROWTH RATES – PERCENT			
1962-1977	4.5	7.5	23.9	7.9	3.5	5.6	6.9
1977-1987	6.6	6.1	7.1	10.0	5.0	4.7	6.2
1987-2000	4.1	5.4	6.7	5.0	4.6	5.0	5.3

FIGURE 1



OPERATING AREAS IN EASTERN ONTARIO
ACTUAL AND FORECAST DECEMBER PEAK LOADS

FIGURE 2

VANKLEEK HILL OPERATING AREA ACTUAL AND FORECAST SUM OF CUSTOMER DECEMBER PEAK LOADS BY CLASSIFICATION MW

	MUNICIPAL	RETAIL	DIRECT INDUSTRIAL	TOTAL
		ACTUAL		
1962	13	22	96	131
1963	15	21	90	126
1964	16	22	79	116
1965	18	21	78	117
1966	19	28	80	127
1967	21	24	83	128
1968	24	29	85	138
1969	28	31	83	142
1970	30	39	78	147
1971	33	40	78	151
1972	35	44	80	160
1973	41	50	80	171
1974	40	50	80	170
1975	51	69	54	175
1976	56	74	123	252
1977	58	73	121	253
		FORECAST – 780213		
1978	60	80	125	265
1979	65	87	127	279
1980	70	96	137	303
1981	76	105	139	320
1982	83	115	145	343
1983	90	126	149	366
1984	98	138	155	391
1985	107	151	160	417
1986	116	165	165	446
1987	127	180	171	478
		PROJECTION		
1988	133	189	176	498
1989	140	199	180	519
1990	147	209	184	541
1991	155	220	189	564
1992	162	231	193	587
1993	171	243	198	611
1994	179	255	202	636
1995	188	268	206	662
1996	198	281	210	689
1997	208	295	215	717
1998	218	310	219	747
1999	229	325	223	777
2000	240	341	227	809
		GROWTH RATES – PERCENT		
1962-1977	10.5	8.3	1.6	4.5
1977-1987	8.2	9.5	3.5	6.6
1987-2000	5.0	5.0	2.2	4.1

FIGURE 3

WINCHESTER OPERATING AREA ACTUAL AND FORECAST SUM OF CUSTOMER DECEMBER PEAK LOADS BY CLASSIFICATION MW

	MUNICIPAL	RETAIL	DIRECT INDUSTRIAL	TOTAL
		ACTUAL		
1962	231	44	0	274
1963	240	49	0	289
1964	249	32	0	281
1965	277	25	10	312
1966	314	28	10	352
1967	341	32	11	384
1968	420	39	11	470
1969	434	42	14	489
1970	467	52	14	532
1971	503	58	11	572
1972	553	62	10	625
1973	585	67	10	662
1974	601	70	10	681
1975	673	95	12	780
1976	713	101	10	823
1977	705	103	4	812
		FORECAST – 780213		
1978	724	105	14	844
1979	763	115	14	893
1980	809	125	14	948
1981	856	136	14	1006
1982	911	148	15	1074
1983	968	161	15	1144
1984	1028	175	15	1218
1985	1092	190	16	1297
1986	1159	206	16	1381
1987	1230	223	16	1470
		PROJECTION		
1988	1295	239	17	1550
1989	1363	255	17	1635
1990	1434	272	17	1724
1991	1509	291	18	1818
1992	1588	310	18	1916
1993	1670	331	19	2020
1994	1757	354	19	2130
1995	1848	377	20	2245
1996	1943	402	20	2366
1997	2044	429	20	2493
1998	2149	457	21	2627
1999	2259	487	21	2768
2000	2375	519	22	2915
		GROWTH RATES – PERCENT		
1962-1977	7.7	5.8	–	7.5
1977-1987	5.7	8.0	14.9	6.1
1987-2000	5.2	6.7	2.5	5.4

FIGURE 4

ARNPRIOR OPERATING AREA ACTUAL AND FORECAST SUM OF CUSTOMER DECEMBER PEAK LOADS BY CLASSIFICATION MW

	MUNICIPAL	RETAIL	DIRECT INDUSTRIAL	TOTAL
		ACTUAL		
1962	8	0	0	8
1963	8	0	0	8
1964	41	0	0	41
1965	49	0	0	49
1966	59	13	0	72
1967	66	15	0	81
1968	78	17	0	95
1969	85	21	0	106
1970	96	26	0	122
1971	99	27	0	127
1972	108	33	0	141
1973	116	34	0	150
1974	120	38	0	158
1975	133	51	0	183
1976	139	57	0	196
1977	141	58	0	198
		FORECAST – 780213		
1978	149	61	0	210
1979	156	68	0	225
1980	163	76	0	240
1981	170	85	0	256
1982	179	95	0	275
1983	188	107	0	295
1984	197	119	0	316
1985	207	133	0	340
1986	217	148	0	365
1987	228	164	0	392
		PROJECTION		
1988	244	178	0	421
1989	260	192	0	452
1990	277	207	0	484
1991	295	223	0	518
1992	314	240	0	554
1993	334	257	0	591
1994	354	276	0	631
1995	376	296	0	672
1996	399	316	0	715
1997	422	338	0	760
1998	447	360	0	807
1999	472	383	0	855
2000	499	407	0	906
		GROWTH RATES – PERCENT		
1962-1977	21.1	–	0	23.9
1977-1987	4.9	11.0	0	7.1
1987-2000	6.2	7.2	0	6.7

FIGURE 5

PERTH OPERATING AREA ACTUAL AND FORECAST
SUM OF CUSTOMER DECEMBER PEAK LOADS BY CLASSIFICATION
MW

	MUNICIPAL	RETAIL	DIRECT INDUSTRIAL	TOTAL
		ACTUAL		
1962	22	9	0	31
1963	23	9	0	32
1964	25	10	0	34
1965	26	10	0	36
1966	27	15	0	42
1967	28	16	0	44
1968	31	19	0	50
1969	32	23	0	55
1970	38	27	0	64
1971	36	30	0	65
1972	38	31	0	70
1973	39	36	0	76
1974	38	33	0	71
1975	44	48	0	92
1976	48	51	0	99
1977	49	48	0	97
		FORECAST – 780213		
1978	48	57	0	105
1979	49	65	0	115
1980	51	74	0	125
1981	53	85	0	138
1982	55	97	0	152
1983	57	110	0	167
1984	59	126	0	185
1985	62	143	0	205
1986	64	163	0	227
1987	67	185	0	251
		PROJECTION		
1988	70	195	0	265
1989	73	206	0	279
1990	77	217	0	294
1991	80	229	0	309
1992	84	241	0	325
1993	88	253	0	341
1994	92	266	0	359
1995	97	280	0	376
1996	102	293	0	395
1997	106	307	0	414
1998	111	322	0	433
1999	117	337	0	454
2000	122	352	0	475
		GROWTH RATES – PERCENT		
1962-1977	5.5	11.8	0	7.9
1977-1987	3.2	14.4	0	10.0
1987-2000	4.7	5.1	0	5.0

FIGURE 6

BROCKVILLE OPERATING AREA ACTUAL AND FORECAST
SUM OF CUSTOMER DECEMBER PEAK LOADS BY CLASSIFICATION
MW

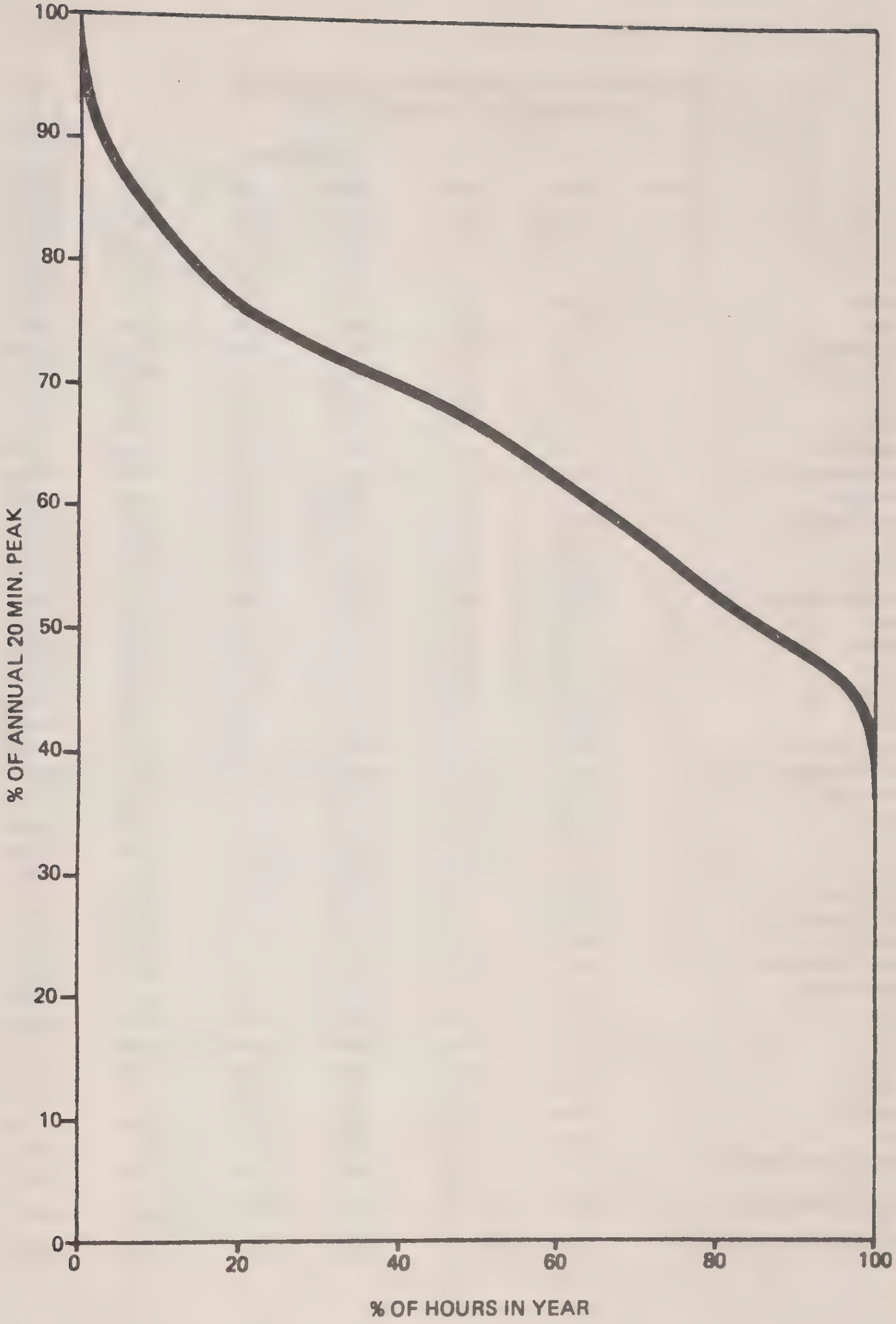
	MUNICIPAL	RETAIL	DIRECT INDUSTRIAL	TOTAL
		ACTUAL		
1962	24	14	51	89
1963	26	15	43	84
1964	27	15	42	84
1965	30	14	40	84
1966	32	15	45	92
1967	33	17	41	91
1968	36	21	45	102
1969	36	27	44	107
1970	39	28	40	107
1971	39	27	42	108
1972	42	33	42	118
1973	45	35	42	122
1974	44	33	42	119
1975	49	46	44	138
1976	52	50	41	143
1977	52	53	42	148
		FORECAST — 780213		
1978	55	54	42	151
1979	57	59	43	159
1980	60	64	42	166
1981	62	69	43	174
1982	65	75	44	184
1983	68	81	45	194
1984	71	87	47	205
1985	74	94	48	216
1986	77	102	49	228
1987	81	110	51	241
		PROJECTION		
1988	86	116	52	253
1989	91	122	53	266
1990	97	128	54	279
1991	103	134	56	293
1992	109	141	57	307
1993	115	148	58	321
1994	121	155	59	336
1995	128	162	61	351
1996	135	170	62	367
1997	143	177	63	383
1998	150	184	64	399
1999	158	192	66	416
2000	167	200	67	434
		GROWTH RATES — PERCENT		
1962-1977	5.3	9.3	—	3.5
1977-1987	4.5	7.6	2.0	5.0
1987-2000	5.7	4.7	2.1	4.6

FIGURE 7

KINGSTON OPERATING AREA ACTUAL AND FORECAST SUM OF CUSTOMER DECEMBER PEAK LOADS BY CLASSIFICATION MW

	MUNICIPAL	RETAIL	DIRECT INDUSTRIAL	TOTAL
		ACTUAL		
1962	49	25	48	122
1963	50	25	46	120
1964	54	25	66	145
1965	58	32	65	155
1966	59	31	66	156
1967	63	33	67	162
1968	70	42	62	174
1969	70	44	62	176
1970	80	59	57	197
1971	78	63	62	203
1972	88	68	67	222
1973	89	76	80	244
1974	90	73	76	239
1975	92	90	79	261
1976	100	96	83	280
1977	102	93	84	278
		FORECAST – 780213		
1978	98	98	85	282
1979	101	106	91	298
1980	103	115	93	310
1981	105	124	95	324
1982	108	134	101	343
1983	111	144	104	360
1984	114	156	108	378
1985	117	168	112	397
1986	120	180	116	417
1987	124	194	121	438
		PROJECTION		
1988	131	207	124	461
1989	138	220	127	485
1990	146	234	130	510
1991	154	249	133	536
1992	163	265	136	563
1993	171	281	139	591
1994	180	299	142	621
1995	189	318	145	652
1996	198	338	148	684
1997	207	359	151	717
1998	216	382	154	752
1999	226	405	157	788
2000	236	431	160	826
		GROWTH RATES – PERCENT		
1962-1977	5.0	9.2	3.8	5.6
1977-1987	2.0	7.6	3.7	4.7
1987-2000	5.1	6.3	2.2	5.0

FIGURE 8



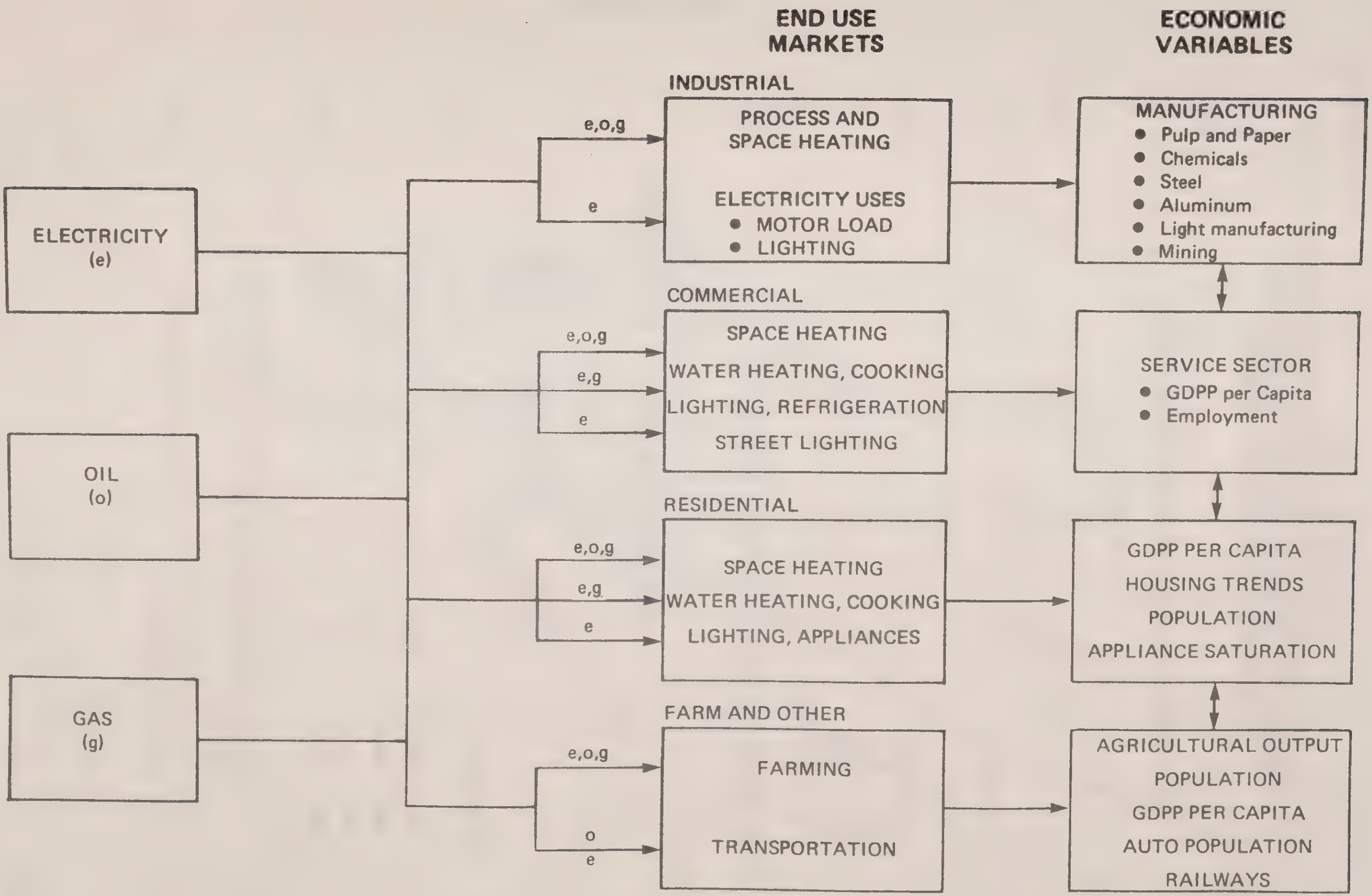
EAST SYSTEM
1977
ANNUAL PERCENT DURATION CURVE OF HOURLY DEMANDS

FIGURE 9

FORECAST OF OTTAWA AREA STATION LOADS COINCIDENT WITH JANUARY PEAK

Station	Load (MW) 1979	1981	1986	1991	1996	2001
Hawkesbury Area	81.1	99.8	162.0	204.8	250.1	304.9
South March	92.6	47.1	78.0	107.7	158.9	221.7
"Almonte"	–	–	58.0	80.2	106.1	137.1
Hawthorne	90.5	78.1	118.9	170.7	237.0	327.6
St. Isidore	58.6	70.1	94.4	124.8	159.4	203.3
Ottawa-Albion	76.1	89.7	124.5	160.2	203.6	257.9
Ottawa-Russell	33.6	42.7	64.2	82.6	105.0	133.0
Ottawa	83.7	84.0	109.0	140.1	178.2	225.7
Stewartville	14.0	15.3	10.0	13.7	18.4	24.0
Ottawa (NRC)	7.6	8.7	9.7	12.5	15.9	20.2
Ottawa-Woodroffe	77.3	31.1	40.9	52.6	66.8	84.6
"Goulbourn"	–	–	24.6	42.7	42.7	42.7
Ottawa Riverdale	44.4	50.7	74.9	96.3	122.5	155.2
Navan	4.9	5.8	6.4	9.1	12.6	17.3
Richmond	4.3	3.9	3.9	5.5	7.3	9.5
Ottawa-Overbrooke	70.4	80.3	61.3	78.8	100.2	126.9
Cassburn	5.0	6.2	6.8	9.3	12.0	15.5
Hazeldean	5.3	6.6	6.3	9.6	13.6	18.6
Uplands	5.3	6.3	6.4	9.1	12.6	17.5
Clarence	5.9	7.3	11.8	16.1	20.8	26,8
Orleans	3.4	4.0	6.1	8.6	11.8	16.3
Ottawa-Slater	80.5	86.9	106.0	136.4	173.4	219.6
Ottawa-"Montreal Road"	–	–	53.5	68.8	87.5	110.8
Ottawa-Lisgar	55.8	62.2	78.8	101.4	128.8	163.2
Rockland	5.8	6.8	9.8	13.6	18.3	24.6
NAE.	0.6	0.6	0.6	0.7	0.8	0.8
Hawkesbury	12.3	13.5	20.2	27.5	35.3	45.3
Bilberry Creek	11.1	15.4	36.2	51.1	71.0	98.3
Nepean (Epworth)	14.4	14.4	14.2	18.6	25.4	33.6
Arnprior TS	43.6	52.0	52.6	74.3	101.6	136.0
Ottawa-King Edward	68.5	77.4	103.1	132.6	168.6	213.6
Ottawa-Hinchey	36.1	40.5	56.4	72.6	92.3	116.9
Merivale	14.4	14.4	14.2	18.6	25.4	33.6
"Nepean"	–	95.5	119.0	164.2	230.6	311.5
Cumberland	5.1	6.0	6.6	9.4	12.9	17.8
Manotick	8.9	10.5	9.3	10.2	14.1	19.3
Manordale	14.4	14.4	14.2	18.6	25.4	33.6
Cyrville	14.6	14.7	16.4	23.1	32.1	44.5
Ottawa-"Lincoln Heights"	–	69.5	90.5	116.4	147.9	187.4
Total Peak Load (MW)	1150.1	1332.4	1879.7	2493.1	3246.9	4196.7
Total Annual Energy (GW.h)	6230	7070	10000	13300	17300	22400

FIGURE 10



CONCEPTUAL FRAMEWORK FOR SRI–CEA MODEL

FIGURE 11

EASTERN ONTARIO
EFFECT OF VARIATIONS IN GROWTH RATE OF GROSS DOMESTIC PROVINCIAL PRODUCT ON GROWTH IN DEMAND FOR ELECTRIC ENERGY

A. Growth Rates in Gross Domestic Provincial Product

	Scenario		
Time Period	#1 SRI Growth Rates %	#2 OEC Growth Rates % Note 1	#3 High Growth Rates %
1976 – 1981	3.8	5.3	5.5
1981 – 1985	3.8	4.4	5.5
1985 – 1990	3.8	4.1	4.5
1990 – 2000	3.2	4.1	4.5

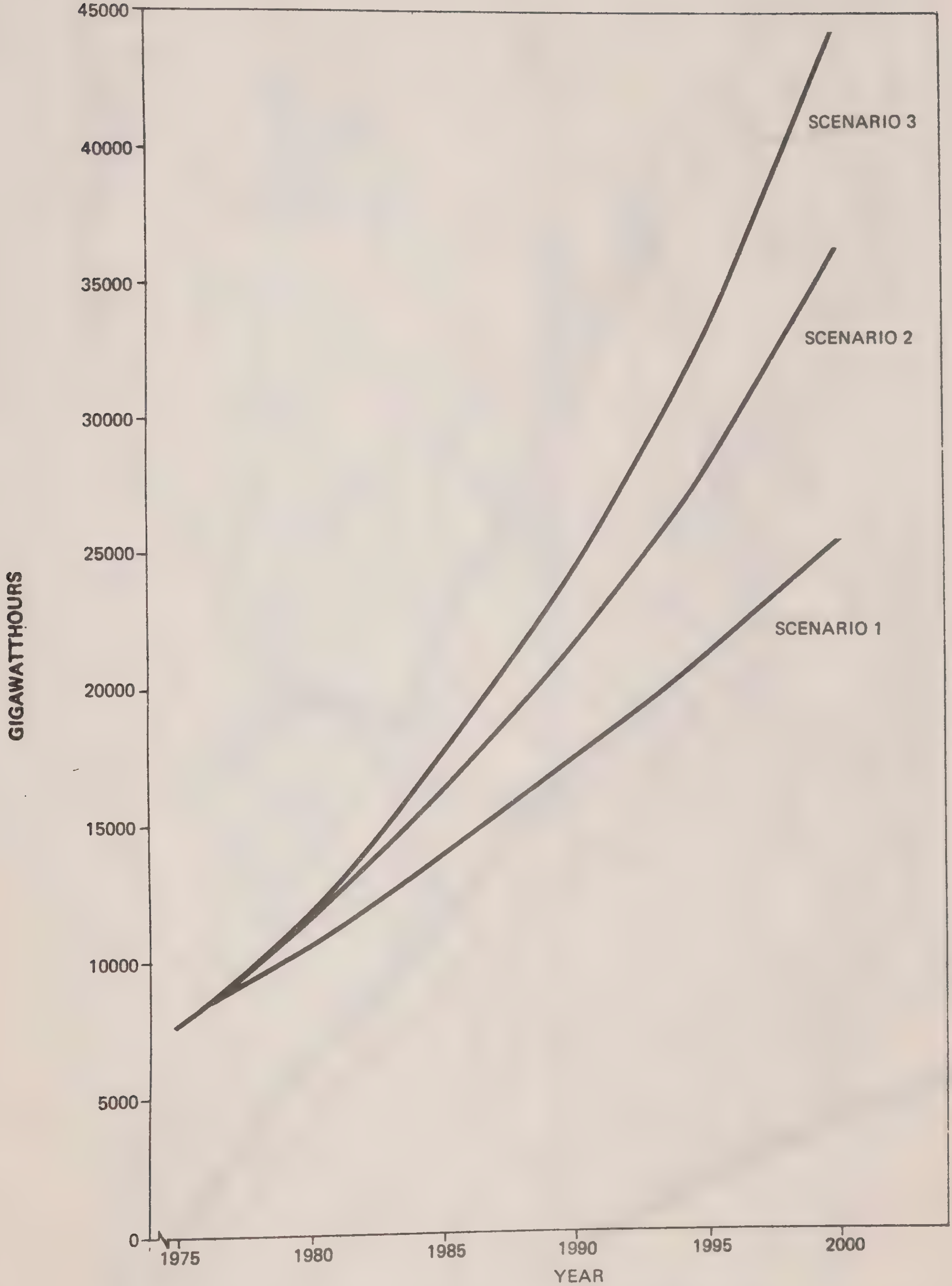
B. Growth Rates in Electric Energy Consumption

	Based on SRI-CEA Model Scenario			Based on Ontario Hydro Forecast 780213
Time Period	#1 SRI Growth Rates %	#2 OEC Growth Rates %	#3 High Growth Rates %	Ontario Hydro Growth Rates % Note 2
1976 – 1981	5.8	8.2	8.5	4.4
1981 – 1985	5.5	6.7	8.6	6.7
1985 – 1990	4.9	5.7	6.5	5.9
1990 – 2000	3.8	5.5	6.3	5.2

Note 1 These figures are approximations of year by year data given in the Ontario Economic Council (OEC) Report for the period to 1987.

Note 2 The Ontario Hydro forecast growth rates are for December peak loads from figure 1.

FIGURE 12



EASTERN ONTARIO
SRI – CEA MODEL FORECAST OF ELECTRIC
ENERGY GROWTH

FIGURE 13

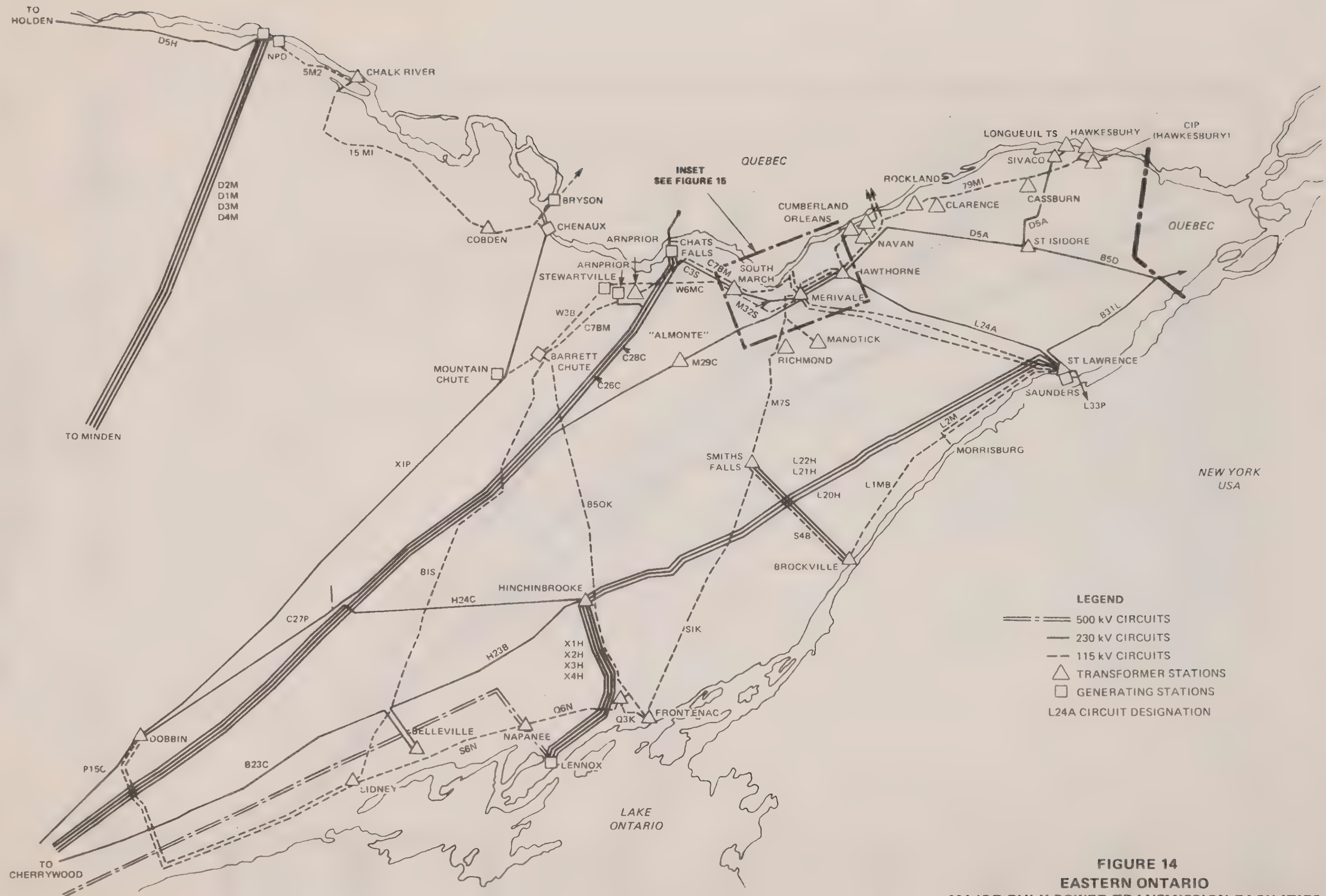
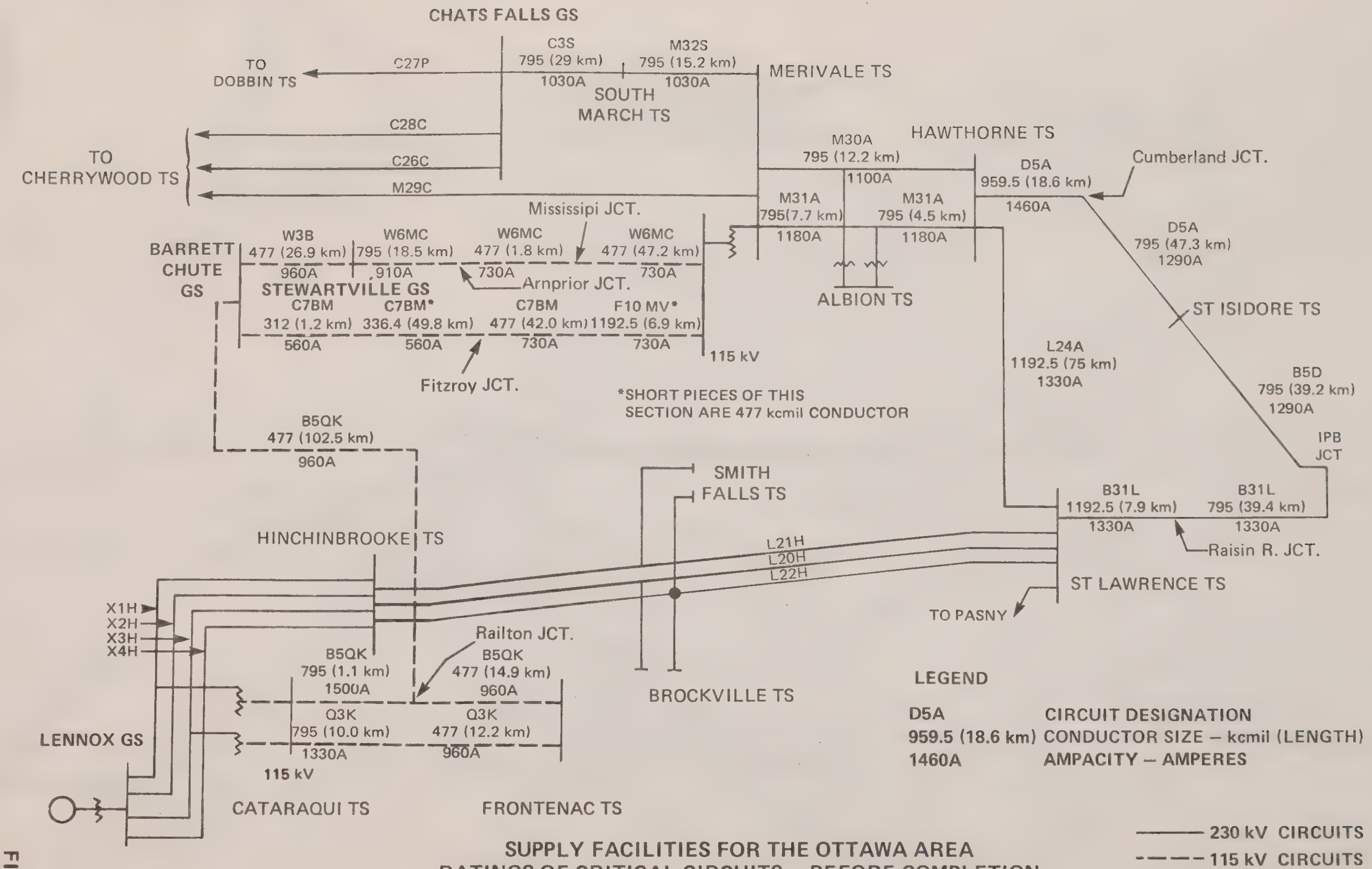


FIGURE 14
EASTERN ONTARIO
MAJOR BULK POWER TRANSMISSION FACILITIES

FIGURE 14

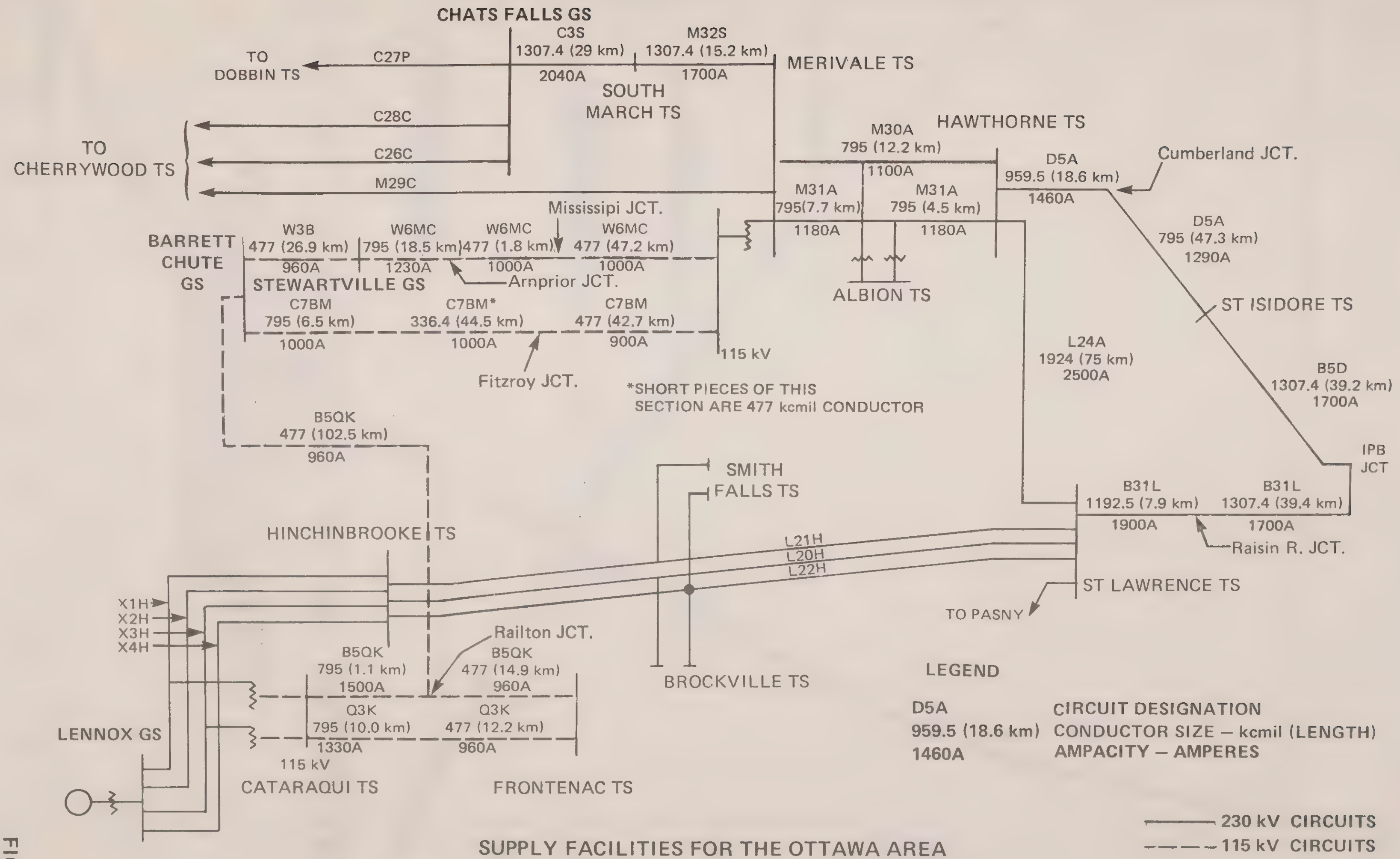
OTTAWA AND VICINITY
MAJOR BULK POWER
TRANSMISSION FACILITIES

FIGURE 15



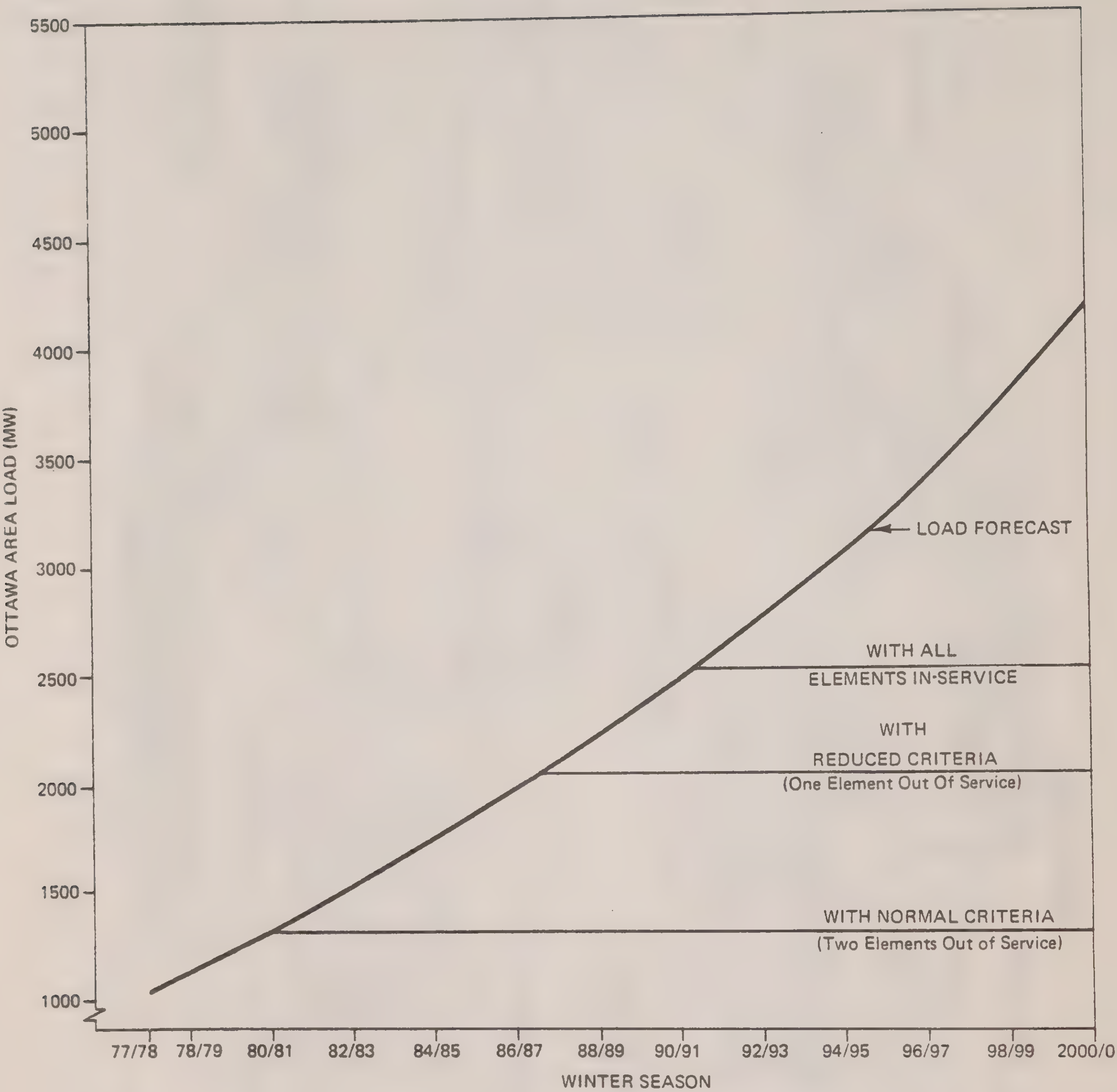
**SUPPLY FACILITIES FOR THE OTTAWA AREA
RATINGS OF CRITICAL CIRCUITS – BEFORE COMPLETION
OF STOP-GAP WORK**

FIGURE 16



SUPPLY FACILITIES FOR THE OTTAWA AREA
RATINGS OF CRITICAL CIRCUITS – AFTER COMPLETION
OF STOP – GAP WORK

FIGURE 17



CAPABILITY OF BULK POWER TRANSMISSION SYSTEM TO SUPPLY THE OTTAWA AREA LOAD AFTER COMPLETION OF STOP-GAP WORK
(Load Coincident with System Winter Peak)

FIGURE 18

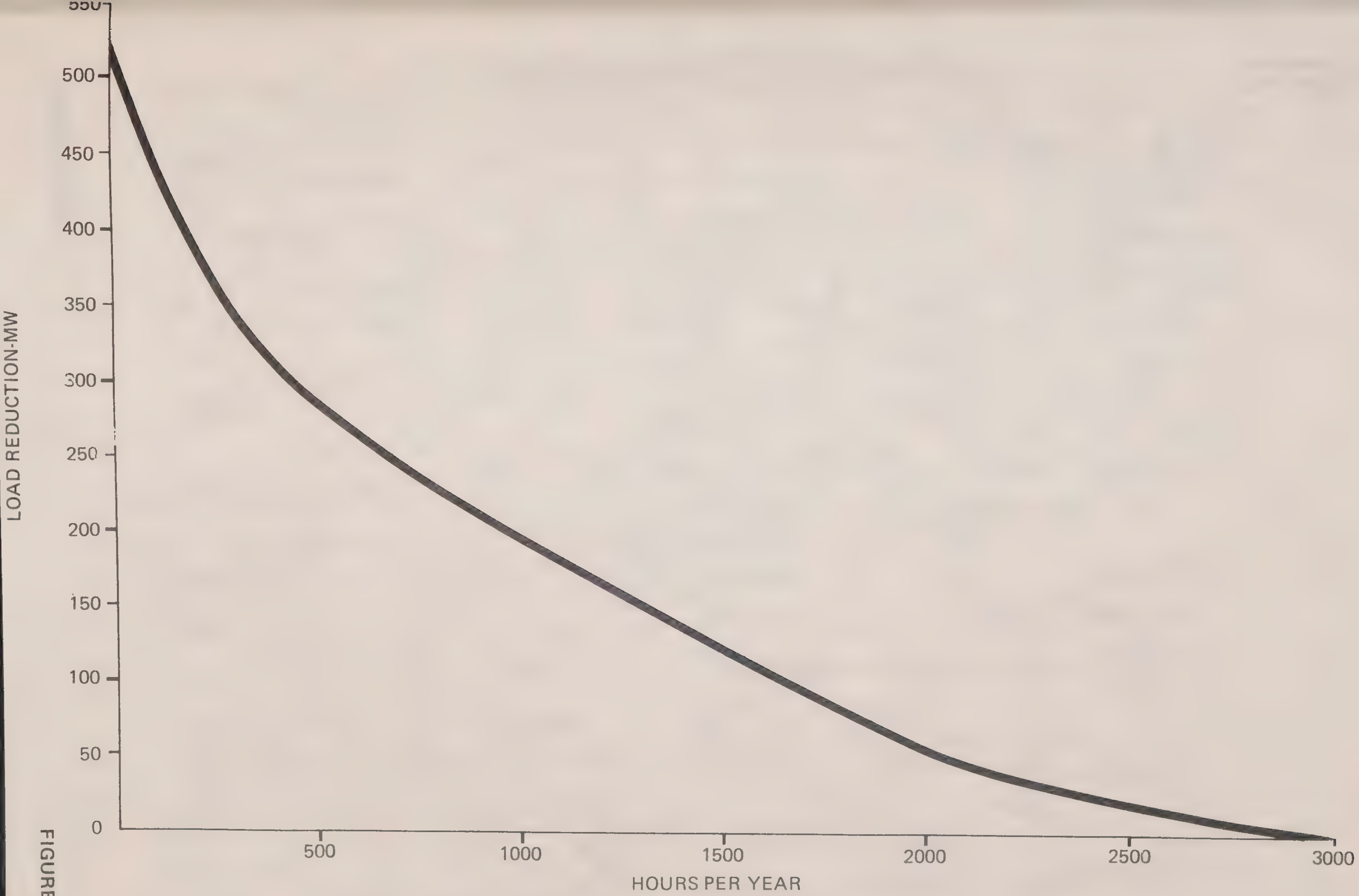
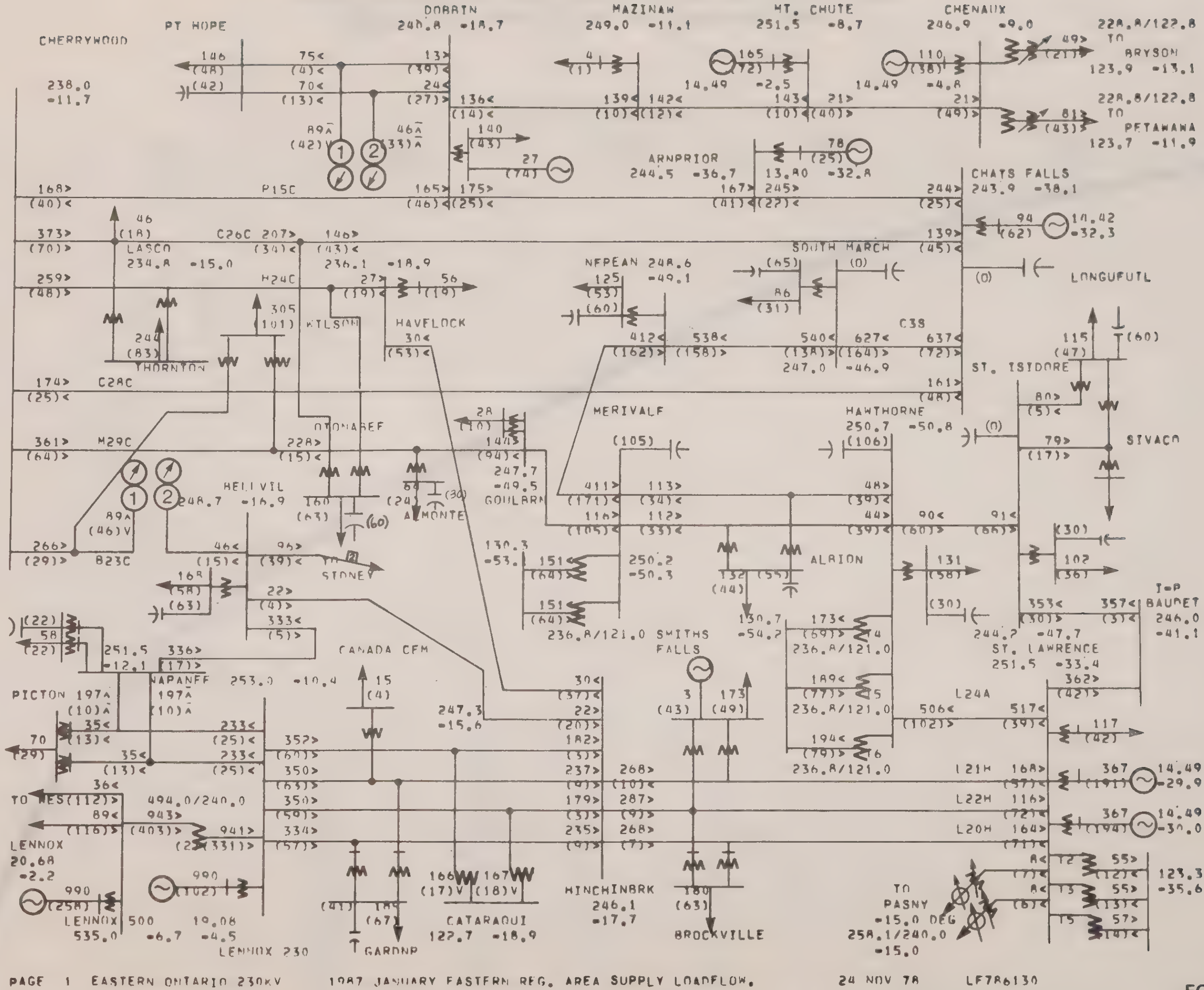


FIGURE 19

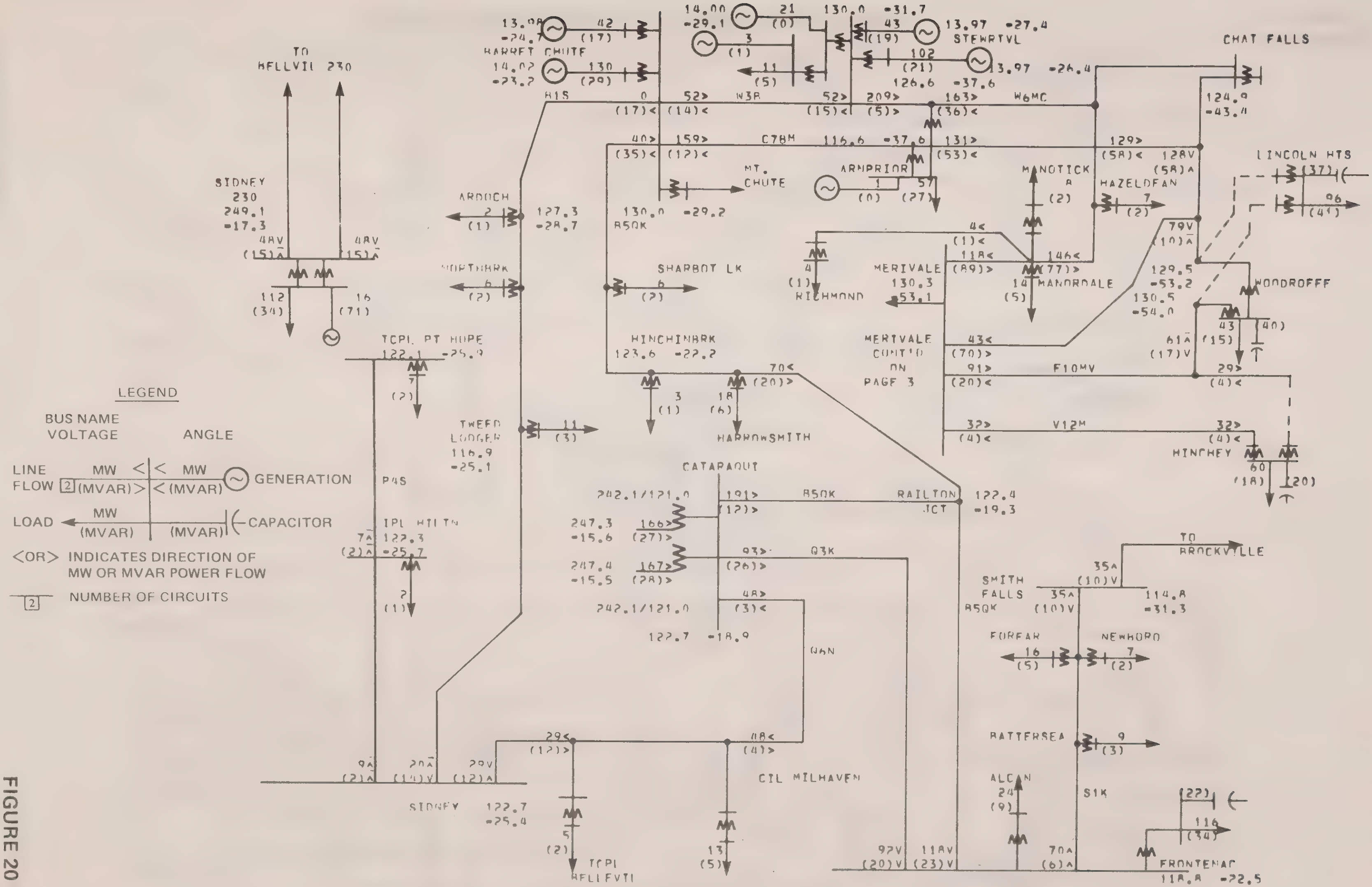
AMOUNT OF LOAD IN EXCESS OF TRANSMISSION
CAPACITY (NORMAL CRITERIA) VERSUS DURATION – 1986



LOAD FLOW PLOT WITH ALL ELEMENTS IN SERVICE

FOR LEGEND SEE PAGE 2

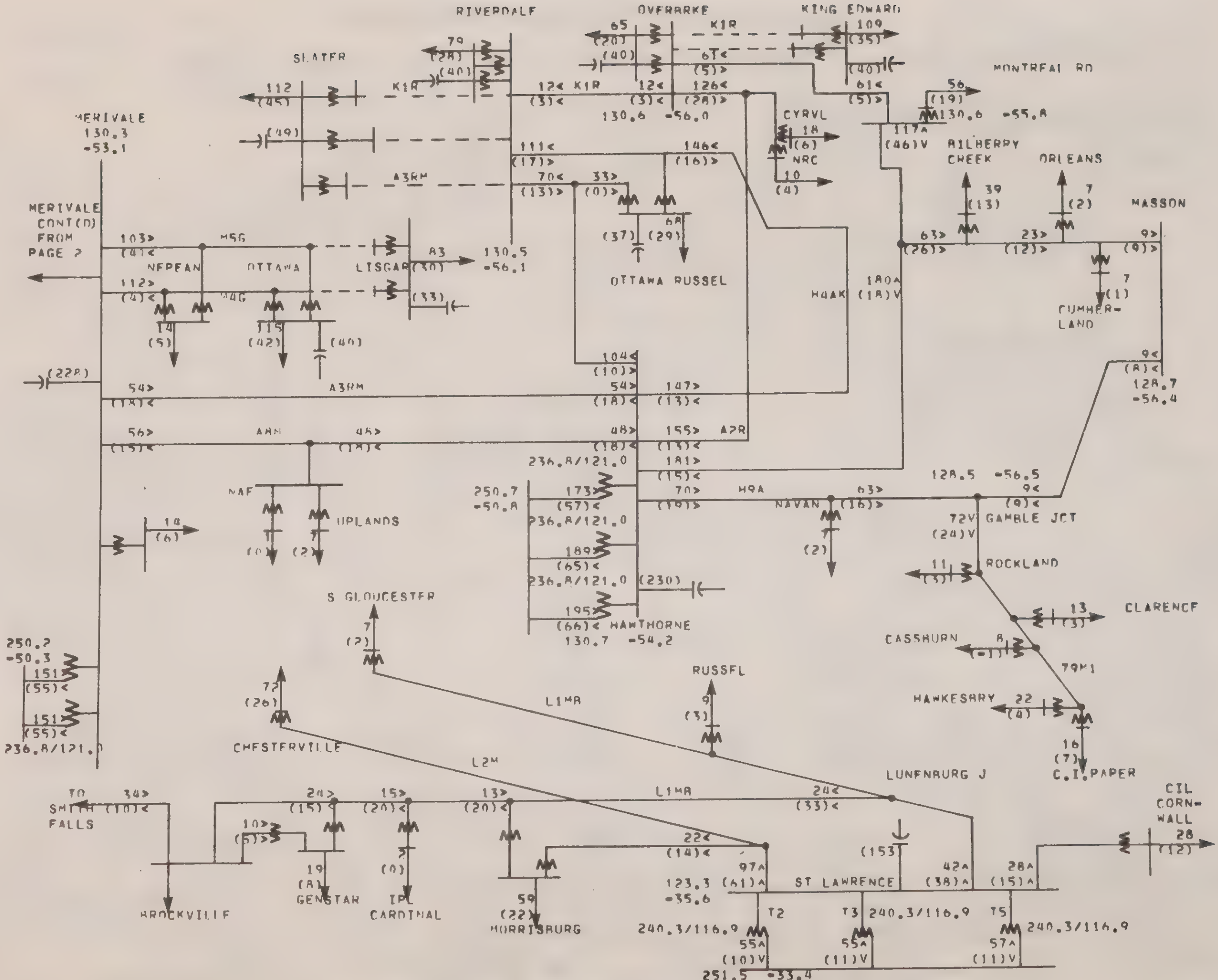
FIGURE 20 (Page 1)



PAGE 2 EAST ONT. KINGSTON AREA 1987 JANUARY EASTERN REG. AREA SUPPLY LOADFLOW. 24 NOV 78 LF7B6130

LOAD FLOW PLOT WITH ALL ELEMENTS IN SERVICE

FIGURE 20 (Page 2)

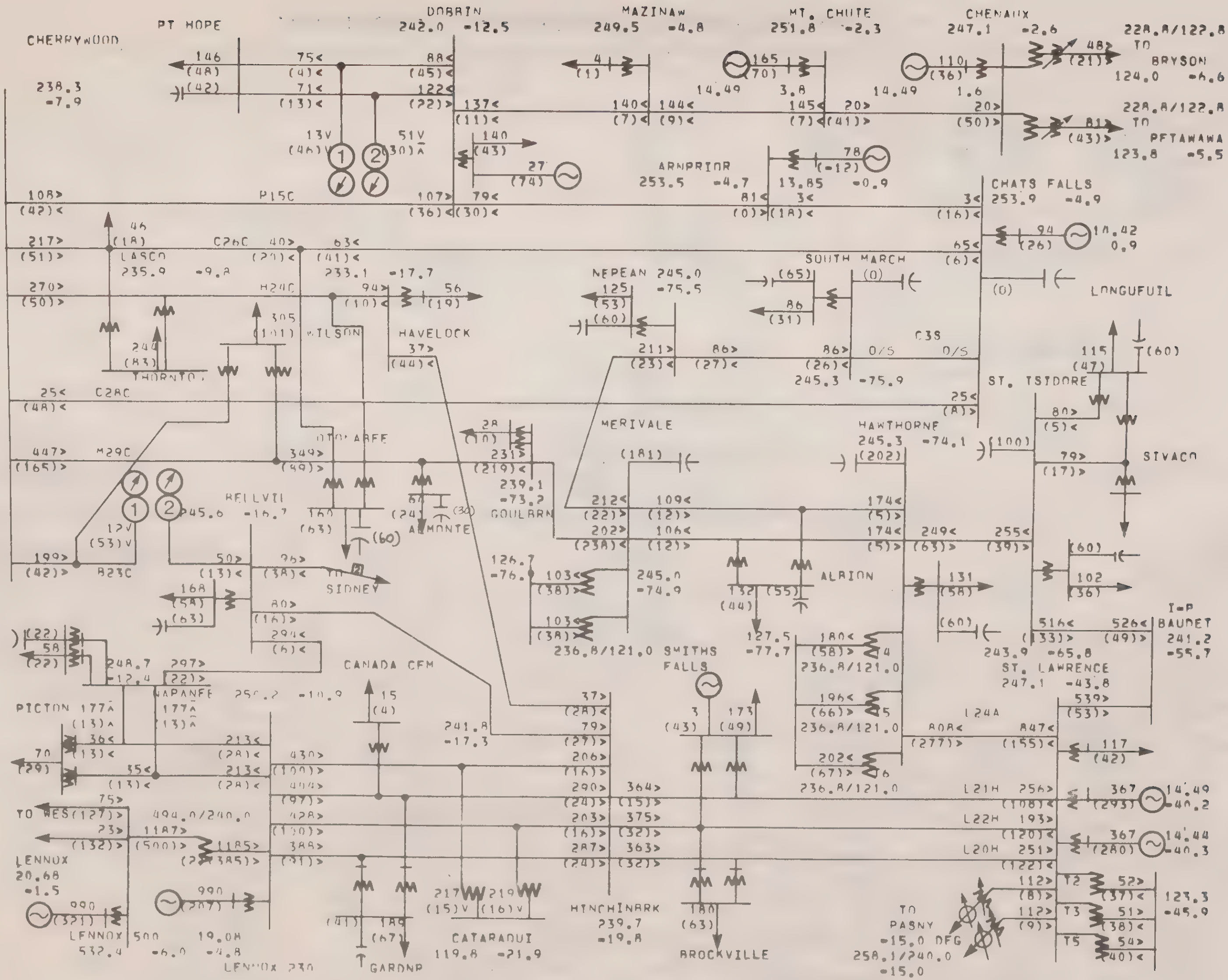


PAGE 3 EAST ONT. OTTAWA AREA 1987 JANUARY EASTERN REG. AREA SUPPLY LOADFLOW. 24 NOV 78 LF786130

LOAD FLOW PLOT WITH ALL ELEMENTS IN SERVICE

FOR LEGEND SEE PAGE 2

FIGURE 20 (Page 3)

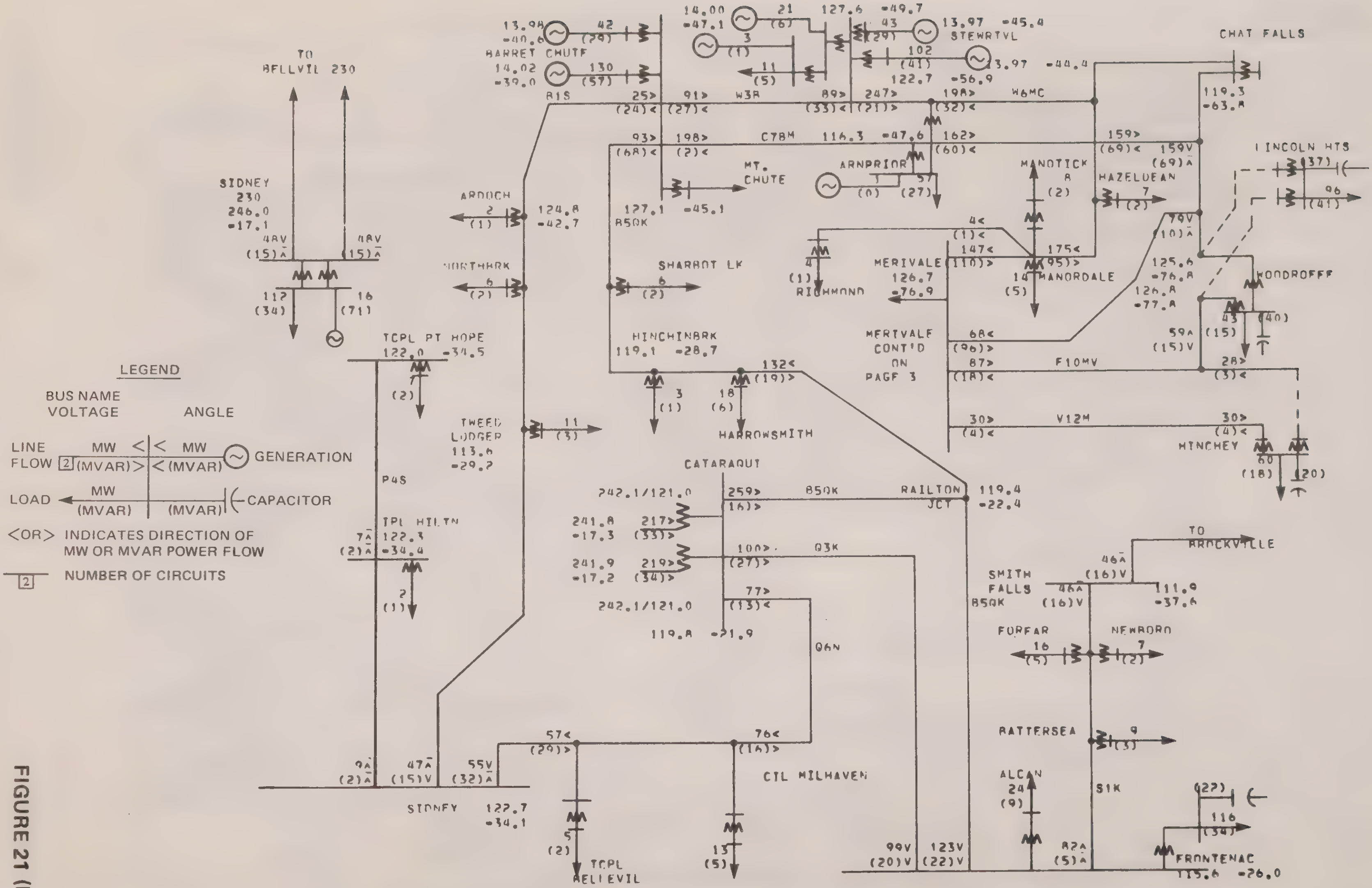


PAGE 1 EASTERN ONTARIO 230KV 1987 JANUARY EASTERN REG. AREA SUPPLY LOADFLOW. 01 DEC 78 LF7A6131

LOAD FLOW PLOT WITH CIRCUIT C3S OUT OF SERVICE

FOR LEGEND SEE PAGE 2

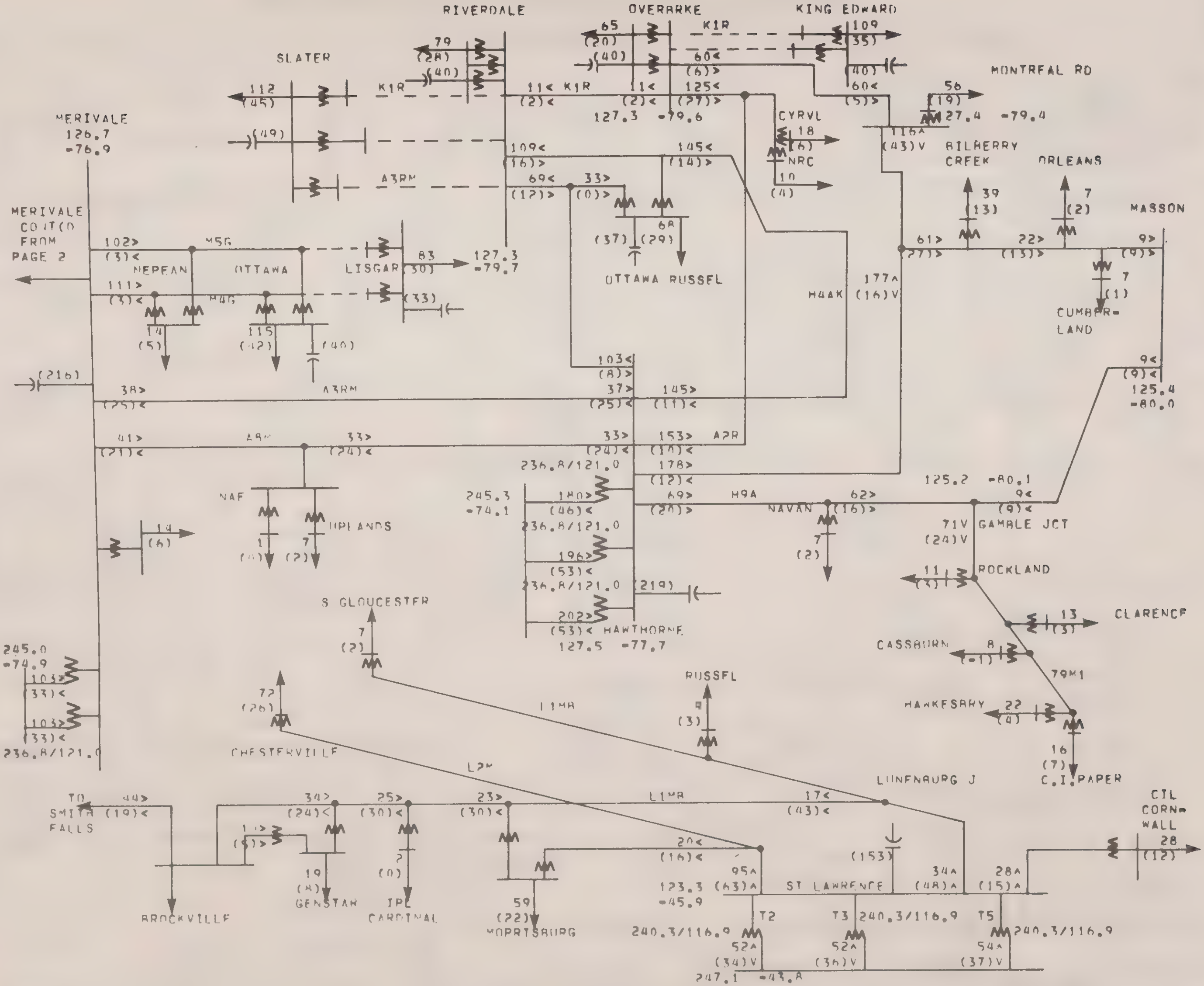
FIGURE 21 (Page 1)



PAGE 2 EAST ONT. KINGSTON AREA 1987 JANUARY EASTERN REG. AREA SUPPLY LOADFLOW. 01 DEC 78 LF786131

LOAD FLOW PLOT WITH CIRCUIT C3S OUT OF SERVICE

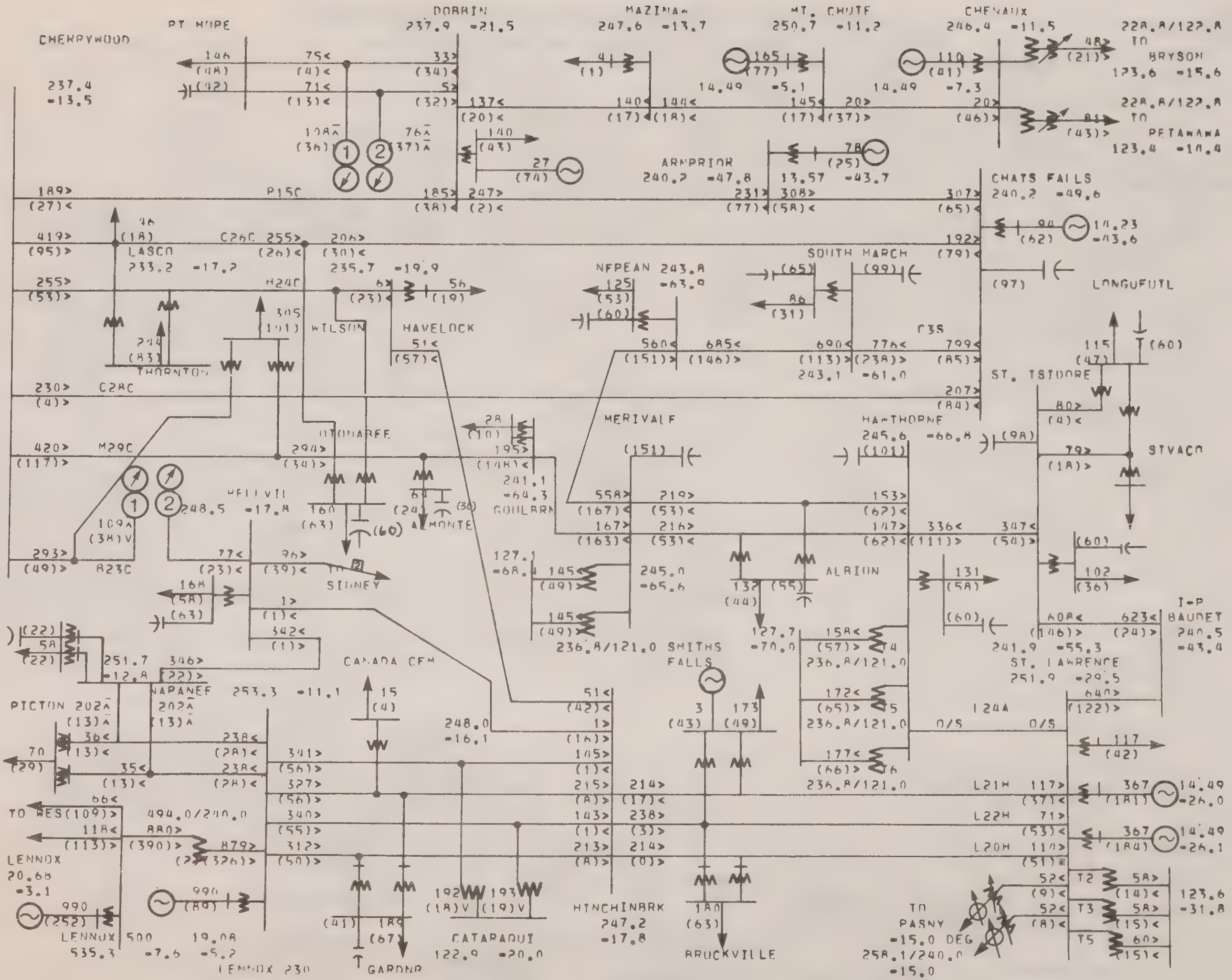
FIGURE 21 (Page 2)



LOAD FLOW PLOT WITH CIRCUIT C3S OUT OF SERVICE

FOR LEGEND SEE PAGE 2

FIGURE 21 (Page 3)

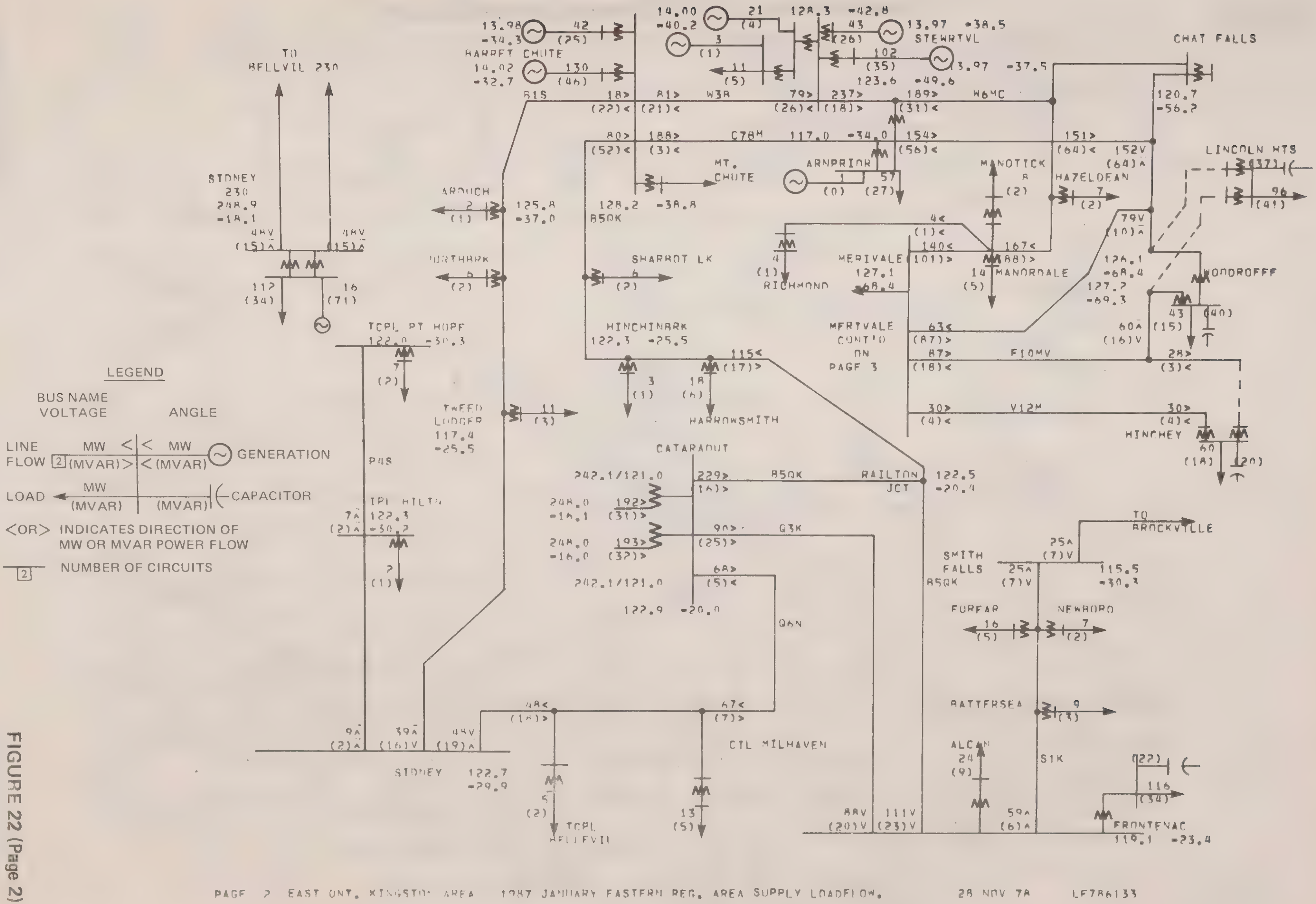


PAGE 1 EASTERN ONTARIO 230KV 1987 JANUARY EASTERN REG. AREA SUPPLY LOADFLOW. 28 NOV 78 LF786133

LOAD FLOW PLOT WITH CIRCUIT L24A OUT OF SERVICE

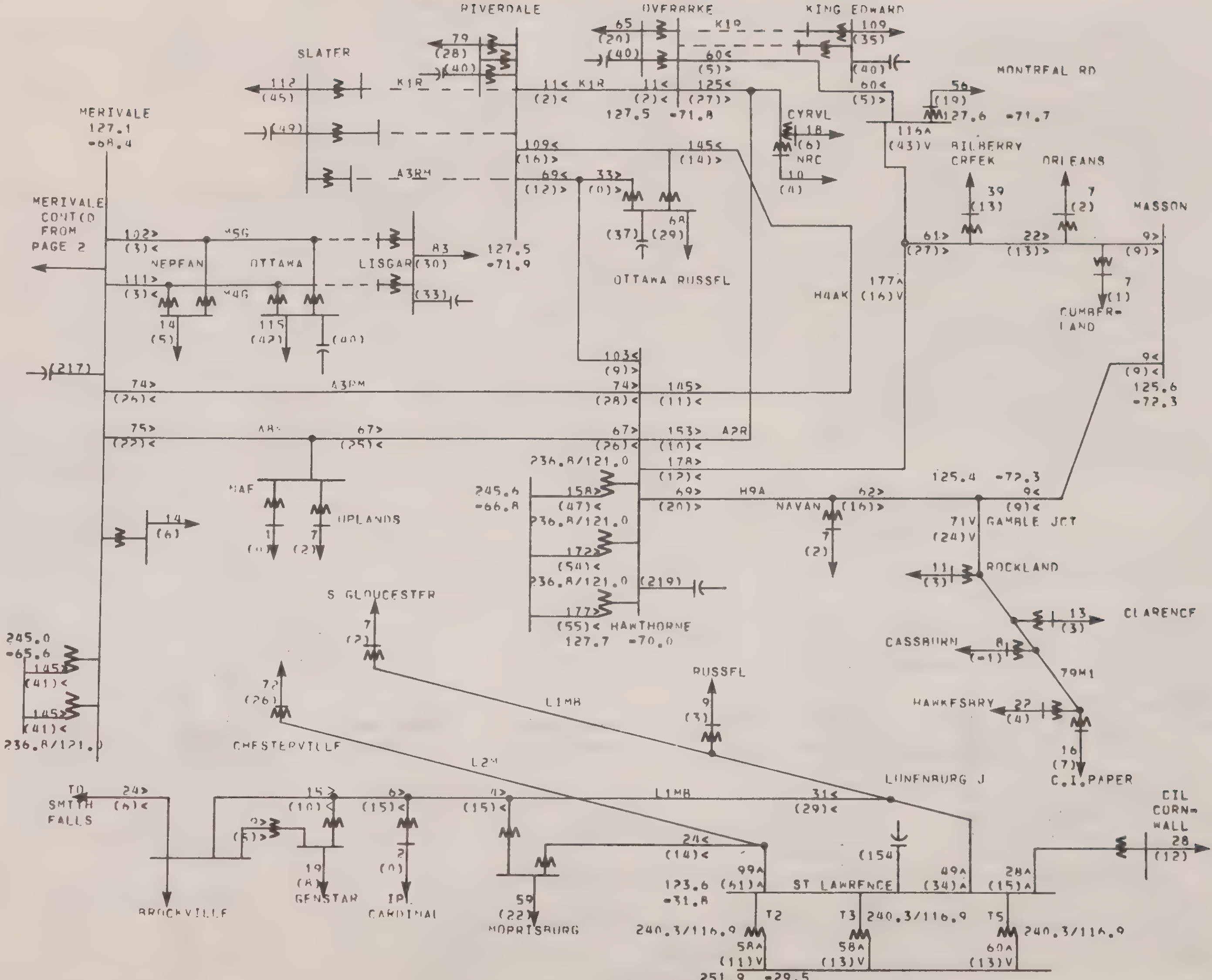
FOR LEGEND
SEE PAGE 2

FIGURE 22 (Page 1)



LOAD FLOW PLOT WITH CIRCUIT L24A OUT OF SERVICE

FIGURE 22 (Page 2)

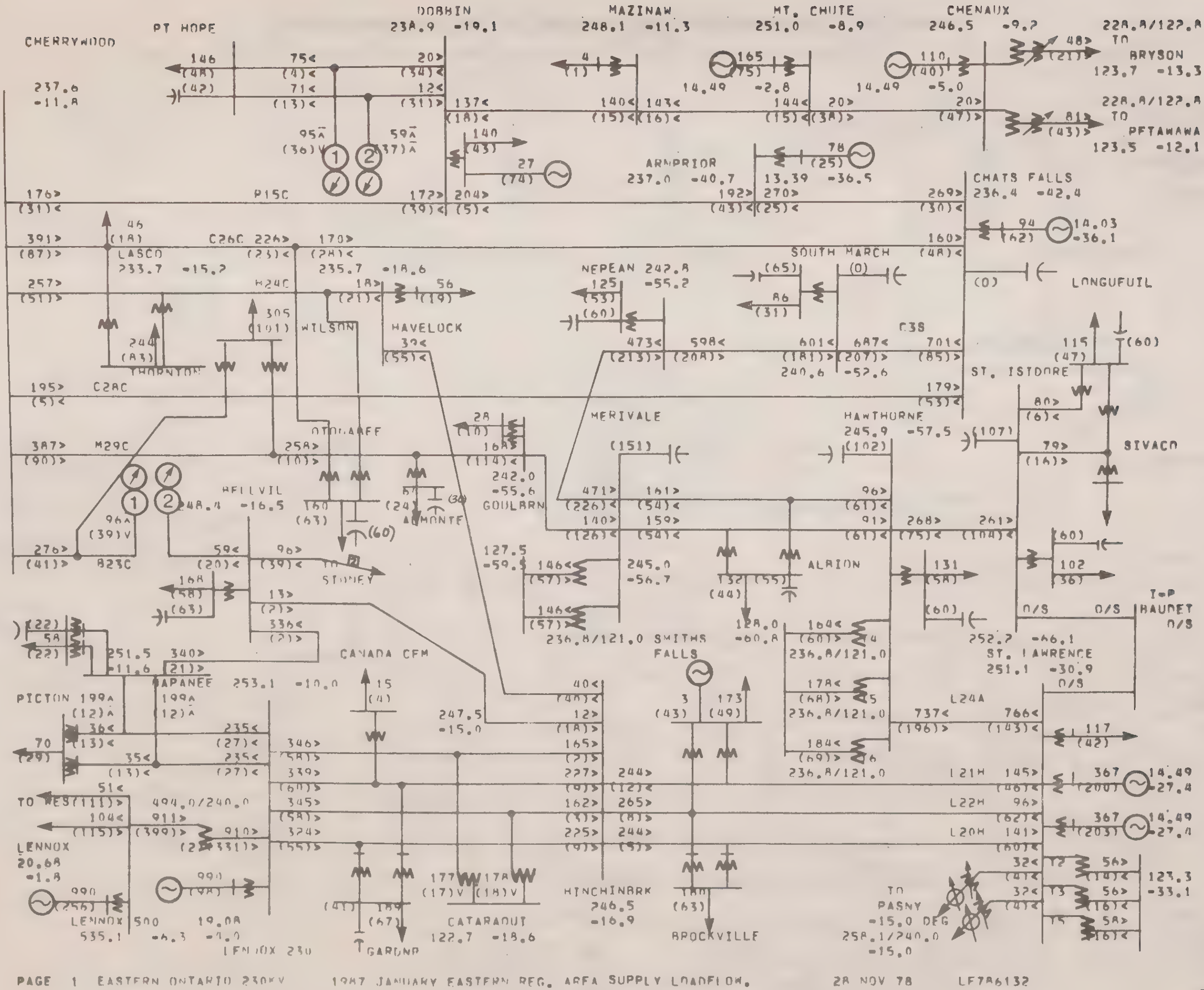


PAGE 3 EAST ONT. OTTAWA AREA 1987 JANUARY EASTERN REG. AREA SUPPLY LOADFLOW. 28 NOV 78 LF786133

LOAD FLOW PLOT WITH CIRCUIT L24A OUT OF SERVICE

FOR LEGEND SEE PAGE 2

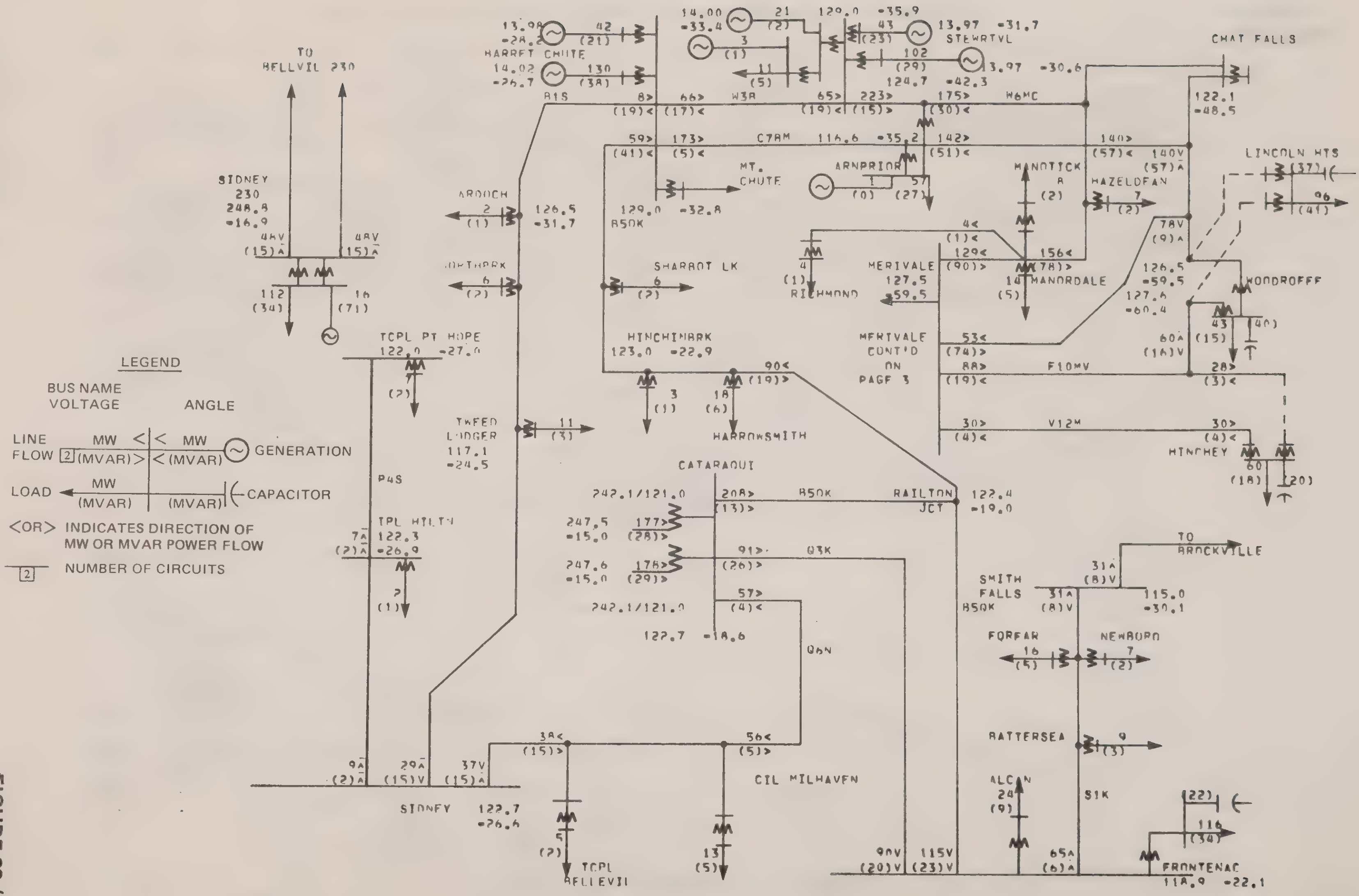
FIGURE 22 (Page 3)



LOAD FLOW PLOT WITH CIRCUITS B31L AND B5D OUT OF SERVICE

FOR LEGEND SEE PAGE 2

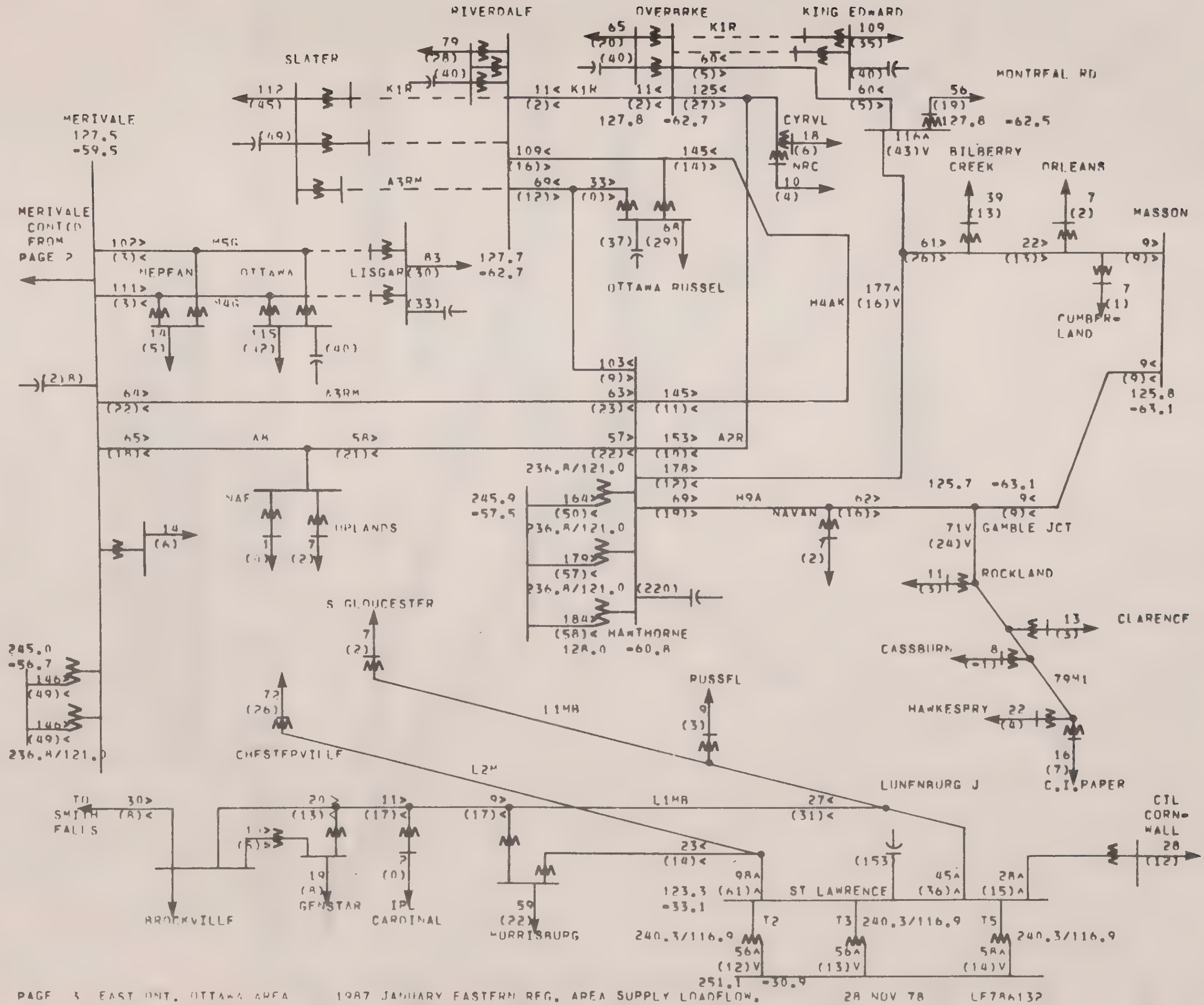
FIGURE 23 (Page 1)



PAGE 2 EAST ONT. KINGSTON AREA 1987 JANUARY EASTERN REG. AREA SUPPLY LOADFLOW. 28 NOV 78 LF786132

LOAD FLOW PLOT WITH CIRCUITS B31L AND B5D OUT OF SERVICE

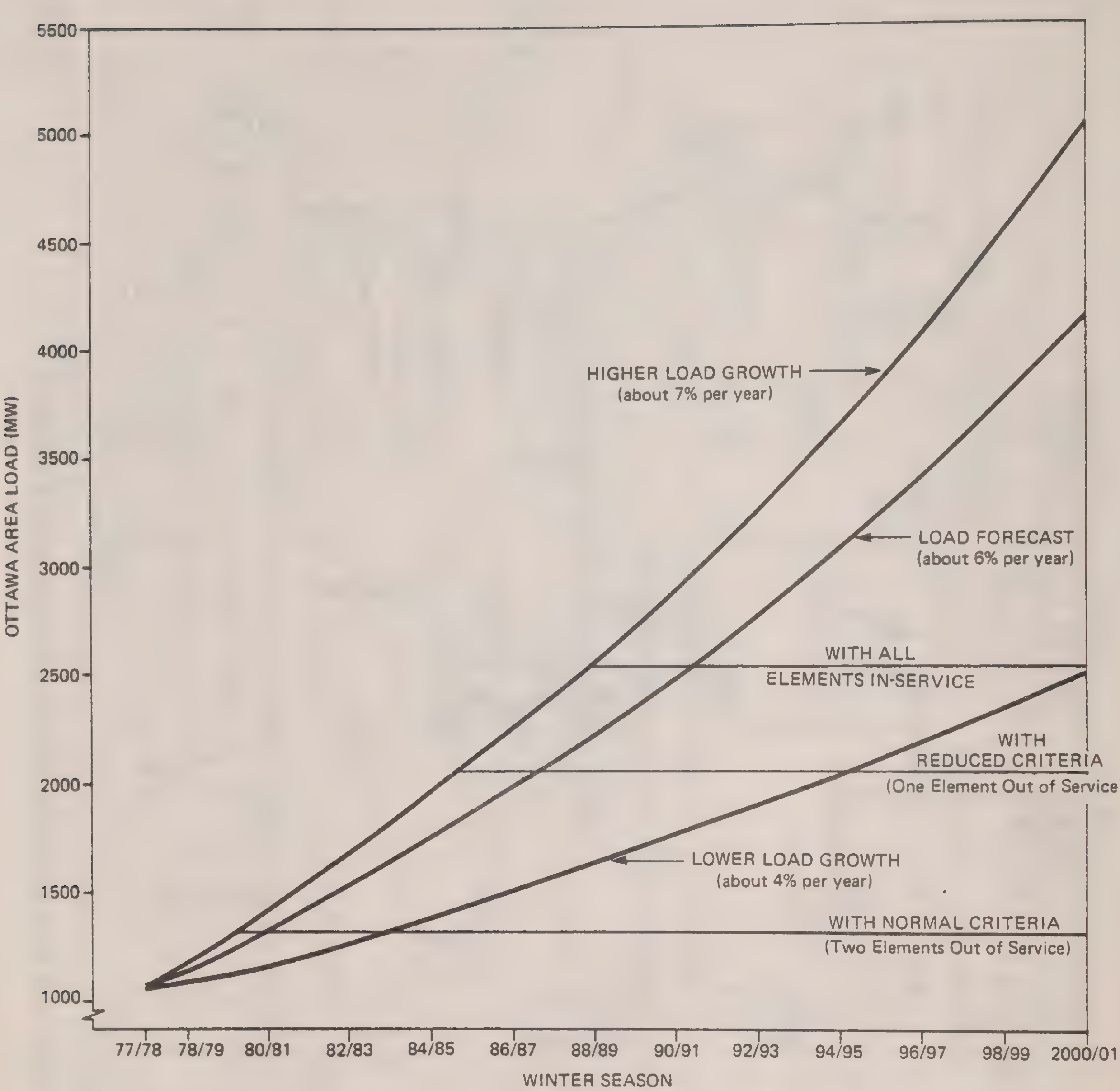
FIGURE 23 (Page 2)



LOAD FLOW PLOT WITH CIRCUITS B31L AND B5D OUT OF SERVICE

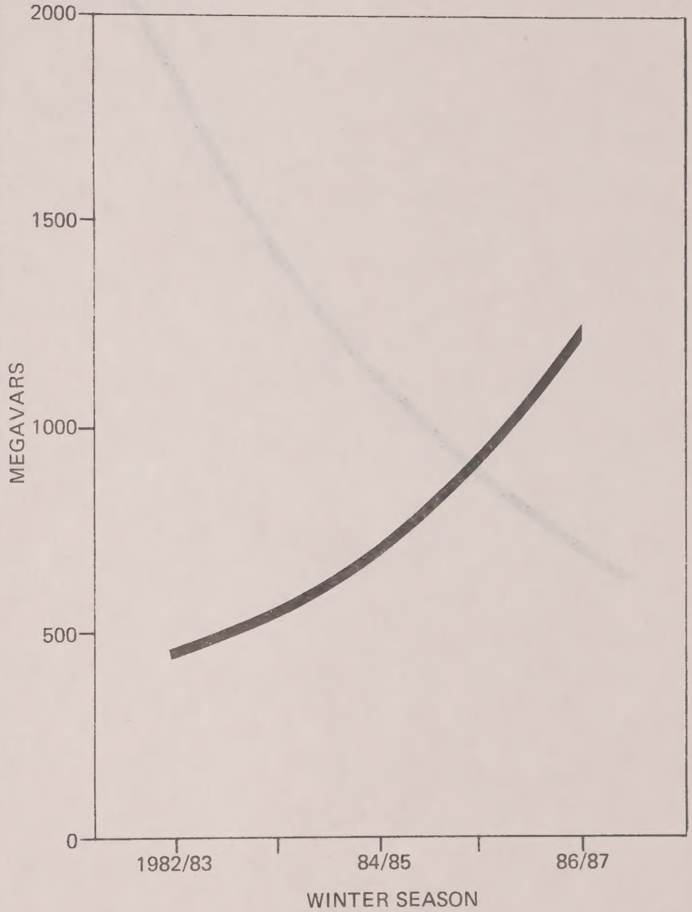
FOR LEGEND SEE PAGE 2

FIGURE 23 (Page 3)



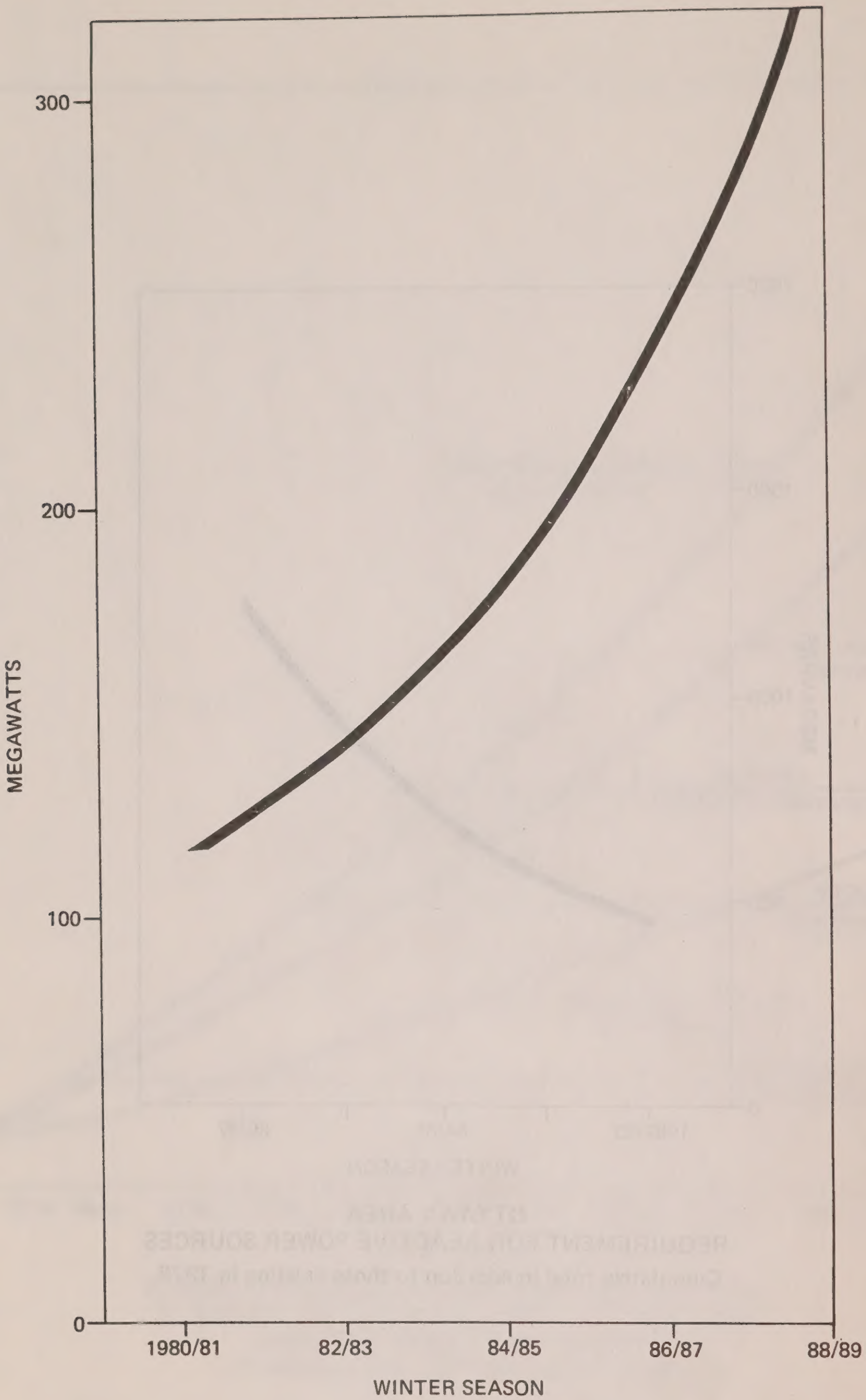
CAPABILITY OF BULK POWER TRANSMISSION SYSTEM TO SUPPLY THE OTTAWA AREA FOR LOADS HIGHER AND LOWER THAN THE FORECAST
(Load Coincident with System Winter Peak)

FIGURE 24



OTTAWA AREA
REQUIREMENT FOR REACTIVE POWER SOURCES
Cumulative total in addition to those existing in 1978.

FIGURE 25



EASTERN REGION
POWER LOSSES IN TRANSMISSION FACILITIES
AT TIME OF SYSTEM WINTER PEAK LOAD
(With All Facilities In-Service and Without Major New Transmission Facilities)

FIGURE 26